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SEISMIC SAFETY
AND
SAFETY ELEMENT
OF THE GENERAL PLAN

PREPARED BY THE
VENTURA COUNTY
ENVIRONMENTAL RESOURCES AGENCY,
PLANNING DIVISION

OCTOBER 1974

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"Where have all the houses gone . . .

Once upon a time people mostly lived in the country and every day as they worked and played they learned about rocks and water. They learned that rocks and water run downhill. So when they built their houses they built them away from running rocks and running water. Today people mostly live in cities and they know about running automobiles and running stores, but they don't know about rocks and water. People build cities almost anywhere: in the desert, in the low valleys and the high mountains, and by the seashore.

Some people like to build their houses in the desert because the desert is dry and the hills are rocky, bold, and clean. But rocky hills are hard, and hard to build on, so the people build their houses in the narrow canyons between the hills. These people don't know why the hills are bold and clean. They are bold and clean because in the dry desert, floods wash away the rock and soil. Then, the rock and soil and water flush down the narrow canyons and through the houses the people build.

Some people like to build their houses in a long straight valley. They don't know why the valley is long and straight. The valley is long and straight because it follows an earthquake fault. Sometimes the fault makes the valley quake, and this shakes the people up while it shakes their houses down.

Some people like to build their houses among the big green trees in the mountains. These people don't know why the trees are big and green. They are big and green because big green trees like lots of rain. The rain that they like sometimes knocks them down then picks them up; rain also picks up rock and soil. Then the rain and trees and rock and soil go bouncing down the canyons and through the houses that the people build.

Some people love the sea so they build their houses on seacliffs. Those who love the sea the most build their houses at the edge. These people don't know why the seacliffs are there because they spend their time looking at the sea and not the cliffs. The seacliffs are there because the land is in the way of where the sea wants to go and that is why they are called seacliffs. The cliff houses are on the land that's in the way of where the sea wants to go, so the cliff houses go too, see?

Some people like to build their houses on soft rocks because soft rocks are easy to build on. But soft rocks can't stand people building on them, so they don't. Soft rocks are sometimes found on little shelves along a hillside or the bumpy ground below. Little shelves and humps on hillsides are called landslides. Most landslides are on their way somewhere, and houses built on landslides that are on their way somewhere are on their way somewhere. ☒

. . . gone to kindling every one "

George B. Cleveland

BACKGROUND

In 1971, the California Legislature passed legislation requiring two new elements to be added to the General Plans of all cities and counties in the State. These were the Safety Element and the Seismic Safety Element.

The impetus for this legislation was a series of natural disasters which had occurred in Southern California in the preceding 2 years. The winter of 1969 saw particularly heavy rains, especially during January and February. Serious flooding occurred in many areas of Southern California but especially in Ventura County. These heavy rains caused substantially increased growth in the Chaparral vegetation belts of the Southern California hills and mountains. Then during thirteen days of September and October, 1970, a series of disastrous fires broke out, fanned by dry desert Santa Ana Winds. The fires burned over half a million acres of brush and timber land, destroyed 722 homes, killed 16 people and cost \$233 million to control. The following winter landslides and mudslides occurred in the hills and damaged many of the structures that had escaped the Fall fires.

In response to these disastrous floods, fires and landslides, the 1971 Legislature enacted Government Code Section 65302.1, which requires of each city and county general plan:

A safety element for the protection of the community from fires and geologic hazards including features necessary for such protection as evacuation routes, peak load water supply requirements, minimum road widths, clearances around structures, and geologic hazards mapping in areas of known geologic hazard.

The impetus for the Seismic Safety Element was the February 9, 1971, San Fernando Valley earthquake. This earthquake of 6.6 magnitude took 65 lives and caused almost \$1 billion of damage to freeway interchanges, hospitals (accounting for the greatest loss of life), utilities, dams, and public, private, commercial and industrial buildings. The earthquake also pointed up major discrepancies in building design and a laxness in land use planning.

This disaster prompted the Legislature to require another element to the general plan, a Seismic Safety Element. Government Code Section 65302 (F) requires:

A seismic safety element consisting of an identification and appraisal of seismic

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hazards such as susceptibility to surface ruptures from faulting, to ground shaking, to ground failure or to the effects of seismically induced waves such as tsunamis and seiches. The seismic safety element shall also include an appraisal of mudslides, landslides, and slope stability as necessary geologic hazards that must be considered simultaneously with other hazards such as possible surface ruptures from faulting, ground shaking, ground failure and seismically induced waves.

Both elements are required to be adopted by September 20, 1974; however, time extensions may be granted under special circumstances. While there was no penalty attached to the original September 20th due date, State authorities have hinted that citizens may be able to bring class action suits against the jurisdictions not complying with the deadlines. Specific penalties may be created if the mandated adoption date is extended by the Legislature; such was the case when the deadline for the Open Space Element was extended.

The preparation of the Seismic Safety and Safety Elements (hereafter referred to as the Seismic and Safety Element) is a coordinated effort between the County of Ventura and the nine cities within the county. It was felt that since most of the hazards are regional rather than local in scope, that a general countywide treatment of each hazard would be more valuable than ten separate, locally oriented elements. The element, then, represents the culmination of participation either directly or indirectly by all cities within Ventura County.

PURPOSE

In preparing the Seismic Safety and Safety Elements, a number of purposes will hopefully be achieved. Among these are:

1. To meet the requirements of State law.
2. To integrate the Seismic Safety and Safety Elements into one coherent document.
3. To investigate the various hazards from a regional as well as a local perspective so as to provide a more integrated picture of the hazardous conditions within Ventura County.

4. To develop a framework which will permit the investigation of all types of hazards and the resources they impact.
5. To present the information collected in a form which will allow decision makers and the public to quickly evaluate the pertinent aspects of a given hazard.
6. To offer a range of response measures from which decision makers may choose as they attempt to alleviate a given hazard.
7. To provide a framework in which future inventory and analysis can be performed.

ORGANIZATION

INTEGRATED ELEMENTS

Because of the confused and overlapping nature of the mandated Seismic Safety and Safety Elements, it was decided to merge the two into one integrated discussion of hazards. This procedure was also recommended by the State General Plan Guidelines.

REGIONAL EMPHASIS

In discussing hazards which affect both incorporated and unincorporated portions of Ventura County, it was necessary to conduct a comprehensive regional study while also providing detailed treatment of local areas and problems. To this end, each hazard is discussed from a regional standpoint prior to being examined at the local level.

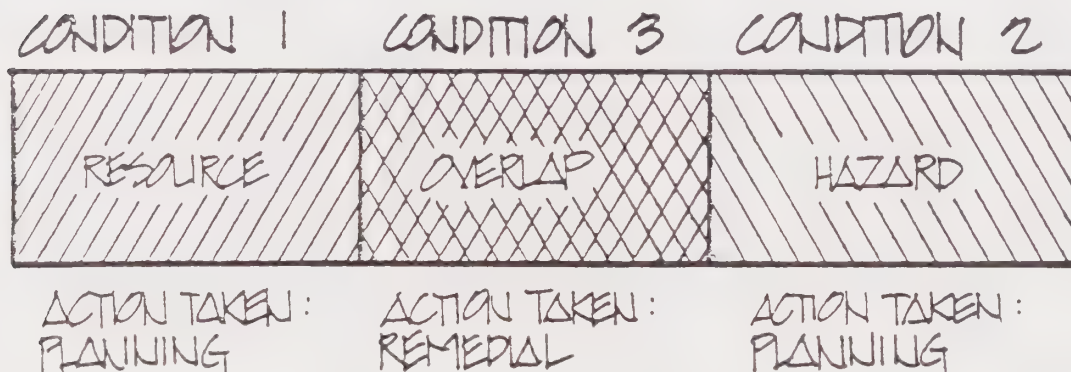
The result of this approach to the two elements, is that each entity will receive one document whose general discussion of the various hazards will be the same as that received by the other entities. Each entity, however, will receive its own individualized discussion of the hazard within its jurisdiction.

ANALYSIS FRAMEWORK

Before embarking on the preparation of the two hazard related elements it was necessary to devise a framework for analysis that would allow the integration of the two elements into one document and permit the systematic investigation of hazards not set out in State law.

The framework decided upon, views hazardous conditions as an interrelationship between resources (natural, human, and man-made) and hazards (natural and man-made). Hazards and resources often exist apart from one another and under such conditions, it is generally concluded that a problem does not exist. For example, landslides in the north half of the county or on Sulphur Mountain are not thought of as hazards because they generally do not affect people or property. Landslides in the Camarillo Hills or immediately above the City of Ventura, however, are usually considered hazardous because they may impact people and property.

The analytic framework, then, identifies three types of conditions: one in which a hazard exists apart from resources; one in which a resource exists apart from hazards; and one in which hazards and resources exist in proximity to one another. In the first two cases, there is an opportunity to plan around the resource or hazard - to prevent hazards from encroaching on resources or to locate resources away from hazards. In the third case where there is an overlap of resources and hazards, planning may not be as effective as various remedial measures.



The Seismic-Safety document has been developed along the lines of this framework in that it identifies resources and hazards, and the instances where they overlap. The hazards are mapped on 1" = 4000' scale maps for the county, 1" = 1000' for the cities and on 11" x 17" sheets contained within the document. Resources will be plotted on transparent sheets which can overlay the 11" x 17" hazard maps.

HAZARD EVALUATION

One of the purposes of the Seismic and Safety Elements is to provide decision makers with the information necessary to evaluate the nature of a given hazard and possible courses

of action. To facilitate this, it is felt that decision makers and the general public should have a general knowledge of a hazard, know where it exists and who is managing it.

In addition, one should know the probability of the hazard occurring, the severity of the hazard should it occur, the resources that are apt to be affected, and the validity of the information which leads to conclusions in the above areas. This information is summarized in the FINDINGS Section of each hazard and should be evaluated and used as a basis for responding to various hazards.

One aspect not addressed in the document, but which will automatically enter into any final decision relative to hazards, is the cost involved. This matter was not addressed because only the local jurisdiction can place values (benefits) on resources that may be lost; and only the local jurisdiction can decide on the appropriate response to a hazard and its attendant costs. A local entity's conclusions about costs and benefits are then the final elements in a Risk Analysis which evaluates: probability, severity, resources, the validity of information, and cost-benefits.

This document, then, attempts to present the available information necessary for a response to a hazardous condition. It does not attempt to make the types of value judgements that ultimately rest with local decision makers.

In addition to the written text, there are a number of maps that accompany each hazard discussed. These maps are an essential part of any hazard evaluation. Hazard zones appear on these maps which depict varying degrees of severity for a given hazard. While these zones are, by necessity, defined by distinct lines, the hazard depicted may not conform exactly to the defined zones. The reasons for this are imprecise data, and small scale maps which do not permit the detailed plotting of data.

For these reasons, the zones that are defined should not be used for specific planning purposes, but rather, should be used to direct more precise studies which would specifically delineate the location and nature of the hazard in question. The various hazard zones, then, define areas of probable hazard which should undergo further study. Additional studies, for example, might be done to allow for more precise planning, or to determine the conditions at a specific construction site.

OPTIONS

After evaluating the information presented on a given hazard and in particular the FINDINGS, an entity must decide on an appropriate response. Responses may range from doing nothing

State, is the notion of "acceptable risk" - "The level of risk below which no specific action by local government is deemed to be necessary."

This issue is addressed by an entity when it performs a Risk Analysis of a given hazard and subsequently decides on an appropriate response. The response that is decided upon implicitly identifies the level of risk that was perceived. If the response is "no action," then it may be concluded that the level of risk is acceptable and perhaps quite low. If on the otherhand, a strong response is issued (such as the immediate abatement of certain structures), then it might be concluded that the level of risk is unacceptable and possibly quite high.

ADDITIONAL INFORMATION

In early 1974 the County of Ventura entered into an agreement with the State Division of Mines and Geology for the preparation of a Geologic Hazards investigation of Ventura County. This 50/50 matching study of \$50,000 will provide additional information relative to the geologic hazards discussed in the Seismic and Safety Elements, upon its completion in June of 1975.

at all to enacting new ordinances. As the assessment of a hazard must ultimately be made by the local jurisdiction, so must the jurisdiction decide what type of response is warranted by its assessment. To assist in this matter, this document offers a range of responses for each hazard from which the jurisdiction may select what it feels are appropriate responses. These prospective responses are termed "options."

The options that are found with each hazard represent a range of implementation measures or concepts from which formal recommendations can be drawn. Before adopting any options, they should be carefully evaluated and coordinated with the agencies and interests, both public and private, which may be affected. They are not intended to be recommendations, but rather a series of alternatives which individually or collectively can be employed to correct a situation or condition identified in the FINDINGS section, which preceded the OPTION section of each hazard.

The range of options is designed to be a pool from which final recommendations can be drawn and proposed by the appropriate staffs to their respective planning commissions, city councils, or Board of Supervisors. The county planning staff then, will not be making recommendations but will offer a range of alternative responses for each hazard from which the staffs from the respective entities may develop recommendations.

This approach was selected because recommendations should come only after a hazard has been assessed in light of local interests and concerns. It was felt that the staffs and citizens of the respective jurisdictions, being in touch with local attitudes, could make more appropriate recommendations than could the county planners preparing the element.

In addition to the specific options offered with each hazard, there is an Options Matrix in the appendix to the Seismic and Safety Elements document which is designed to offer additional response alternatives. A discussion of the Matrix and how to use it can be found in the appendix.

RECOMMENDATIONS ON OPTIONS

To assist the various staffs and decision makers in selecting the appropriate responses to conditions identified in this element, the recommendations of various authorities and advisory groups have been included in the rear of the document. The adoption of these recommendations is not required; they are only intended to guide in the selection of appropriate responses.

ACCEPTABLE RISK

Implicit in the State law mandating a Safety Element, and explicit in the General Plan Guidelines published by the

Civilization exists by geological consent,
subject to change without notice.

Will Durant
What is Civilization?

GENERAL DISCUSSION

GENERAL DESCRIPTION

Surface Faulting (D. R. Nichols, U.S. Geological Survey)

The earth is laced with faults - planes or surfaces in earth materials along which failure has occurred and materials on opposite sides have moved relative to one another in response to the accumulation of stress. Most of these faults have not moved for hundreds of thousands or even millions of years and thus can be considered inactive. Others, however, show evidence of current activity or have moved sufficiently recently to be considered active, i.e., capable of displacement in the near future. Any fault movement beneath a building in excess of an inch or two could have catastrophic effects on the structure, depending upon its design and construction, and the shaking stresses it experiences at the same time. Therefore, it is important to know not only which faults may move but how they might move.

The definition of what constitutes an "active fault" may vary greatly according to the type of land use contemplated or to the importance of the structure. For example, the Atomic Energy Commission regards a fault as active or "capable" with respect to nuclear reactor sites if it has moved "at or near the ground surface at least once in the past 35,000 years;" or "more than once in the past 500,000 years" (Atomic Energy Commission, 1971). Commonly, faults are regarded as active and of concern to land-use planning when there is evidence that they have moved during historic time or, through geologic evidence there may be a significant likelihood that they will move during the projected use of a particular structure or piece of land. Because geologic evidence may be lacking, obscure, or ambiguous as to specific times of past movement, geologists may be able to estimate relative degree of activity only after a regional analysis that may extend far beyond the locality under consideration. Such analysis may be based on historic evidence of fault movement, seismic activity (occurrence of small to moderate earthquakes along the fault trace even though not accompanied by obvious fault movement), displacement of recent earth layers (those deposited during the past 10,000 years), and presence of topographically young fault-produced features (scraps, sag ponds, offset stream courses and disruption of man-made features such as fences, curbs, et.) Movement, however, seldom is limited to a single fault surface throughout the lifetime of a fault system. Faults that commonly produce significant displacement (more than several inches at a time) often have related branches that diverge from the main fault but usually have less movement along them. They may also have secondary faults that are not directly or obviously connected physically to the main

fault trace. Secondary faults are usually nearby (within hundreds of feet of the main rupture) but they may extend as much as several miles away. As with branch faults, displacement along secondary faults is usually only a fraction of that along a main fault.

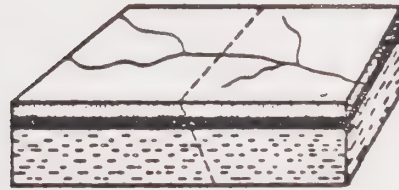
The amount of displacement that can occur during a single earthquake can be related in a general way to the total length of a fault. However, in addition to the location and amount of displacement, the sense of movement is extremely important in estimating the amount and type of damage that might be produced. This was evidenced by the great damage over faults during the moderate (magnitude 6.6) San Fernando Earthquake, which produced a reverse or thrust fault movement. (See Figure 1a). Movement occurred along a similar plane, but in an opposite direction on the normal Wasatch Fault in Utah. (See Figure 1b). Left-lateral movement (Figure 1c) and right-lateral movement, which is common to the San Andreas Fault, probably are less potentially damaging to most structures than normal or thrust faulting.

Not all surface faulting need be rapid nor need it occur during major earthquakes. Imperceptibly slow movement, called "fault creep," occurs along the Hayward, Calaveras, and some other faults, and may be accompanied by micro-earthquakes. Similarly, not all deformation of the earth's surface produces fault displacements. Strains in the earth deform the rocks until their strength is exceeded and they rupture, producing the earthquake. Accompanying this bending, however, is a certain amount of plastic deformation. Both rupture and plastic deformation commonly occur along active fault zones and may be sufficient to damage or destroy structures over particularly strongly deformed rocks. Earthquakes deep within the earth may result from rupture of deeply buried rocks but without fault displacement at the ground surface, although the surface rocks may be deformed (see Figure 1d). This may have been the case along a part of the Newport-Inglewood Fault zone where movement along the fault during the last 10,000 years or so has merely caused a permanent flexuring or bending of the surface rocks.

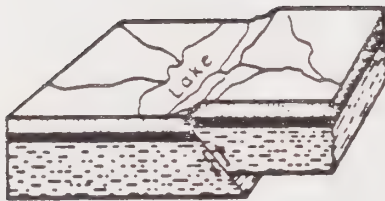
For planning purposes there are two kinds of faults: (1) active faults which have experienced displacement in recent geologic time, suggesting that future displacement can be expected on these faults; and (2) inactive faults that have shown no evidence of movement in recent geologic time, suggesting that these faults are dormant. However, some faults labeled as inactive are so termed due to lack of knowledge. Increased research and monitoring of these faults could reveal some of them as active.

The State Division of Mines and Geology ("Urban Beology," 1973, Bull. 199) indicates that on a state-wide basis the potential hazard to structures from the surface displacement of faults

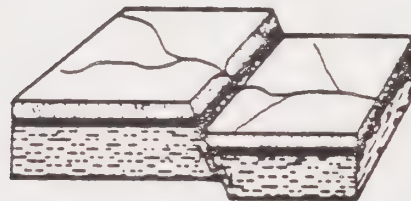
ILLUSTRATION 2.1 EXAMPLES OF SOME TYPES OF FAULT
DISPLACEMENT AND EARTH FLEXURE



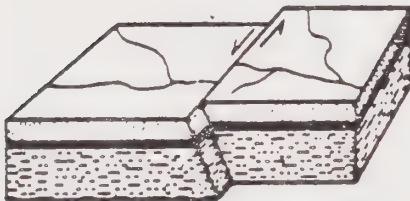
Earth block before movement



1a Thrust or Reverse fault



1b Normal fault



1c Left lateral fault



1d Monoclinal fold caused by
faulting at depth

Source: Tri-Counties Seismic Safety Study, 1973, pg. 68.

is low compared to such geologic phenomena as earthquake shaking and landsliding. Historically, major losses due to fault displacement have been limited to the San Fernando Earthquake of 1971. Structural losses due to fault displacement in the 26 other major earthquakes in California are unknown but were probably small. Most of the losses incurred during the 1906 San Francisco Earthquake and 1952 Tehachapi Earthquake were caused by earthquake shaking and ensuing fires.

GENERAL EFFECTS OF THE HAZARD

PRIMARY EFFECTS

Nearly all man-made structures are susceptible to damage ranging from severe to total when affected by displacement along faults passing beneath their foundations. The San Fernando Earthquake of 1971 has shown that no structures designed under present standards are safe from severe damage or destruction as a result of surface fault displacement of foundations. It is widely acknowledged that design of most structures, such as single family homes or larger structures, roads, bridges, pipelines, or other conduits, to resist fault displacement is generally not feasible. Only massive earth structures such as earthfill dams can be designed to remain functional after several feet of displacement along an underlying fault.

Permanent effects of surface displacements along faults also can include:

1. Abrupt elevation or depression of ground surfaces of several feet for distances of many hundreds of feet along the fault
2. Disruption of surface drainage
3. Changes in groundwater levels in wells
4. Blockage and surface seepage of groundwater flow
5. Changes in survey benchmark elevations
6. Dislocations of street alignments and property lines of many feet if lateral (horizontal) displacement also occurs along a fault, etc.
7. Displacement of drainage channels and drains.

SECONDARY EFFECTS

Secondary effects of surface displacements along faults within an urban area could include:

1. Disruption of movement along roadways due to abrupt depressions or elevation of pavement surfaces.
2. Possible flooding due to disruption of drainage channel and storm drain flow.

3. Disruption of utility services such as water, gas, fuel, telephone and electric power lines.
4. Temporary impact on industry and commerce similar to that resulting from the occurrence of most kinds of regional natural catastrophic events such as hurricanes or floods.

GENERAL INVENTORY OF THE HAZARD

LOCATION AND HISTORY

The greatest potential for fault activity is along any of the faults which lie within the several major fault systems which transect the County from east to west. The recent San Fernando Earthquake which occurred along one of these major fault systems illustrates the high level of activity that some faults within these systems may have and foretells the future occurrence of other such earthquakes in the Los Angeles, Ventura-Santa Barbara region.

The San Fernando Earthquake of 1971 may be an example of the typical type which could occur along some of the east-west trending faults which transect the County. Based upon that earthquake, it is most likely that a surface fault displacement within the County will be sudden, occurring over a period of less than one minute. The displacement would be accompanied by sharp earthquake shaking lasting perhaps several tens of seconds.

The following is a description of the major active and potentially active faults and fault systems within Ventura County (refer to Hazards Plate I):

Malibu-Santa Monica-Raymond Fault System

This fault system is believed to consist of a series of major north-dipping thrust faults which extend along the coast and onshore for a total of over 40 miles and perhaps a much greater distance offshore in the Santa Barbara channel. It begins in the San Bernardino area and extends along the southern base of the Santa Monica Mountains and passes offshore a few miles west of Point Dune.

Geologic evidence for activity of the fault system during recent geologic time up through the present are faulted Terrace and near surface sedimentary deposits, groundwater barriers and the recent Point Mugu Earthquake (February, 1973) which is believed to have originated on the Malibu Fault.

The faults within this system are considered active.

Simi-Santa Rosa Fault

This fault is associated with reverse or high angle thrust movement. From the Santa Susana Mountains westward along the northerly margin of the Simi and Tierra Rejada Valleys, along the south slope and crest of the Las Posas Hills to their westerly termination. The presence of the Springville and Camarillo Faults short distances to the north and south, respectively, of the westerly projection of the Simi-Santa Rosa Fault suggest a relationship to these faults which project into the Oxnard Plain along the trend of the subject fault.

Surface evidence north of Simi Valley indicates that at least the easterly portion of this fault has been active during Pleistocene time (11,000 to 3,000,000 years before present). However, available information is considered insufficient to conclude that westerly portions of the Fault have not been active during the Pleistocene or more recent time. No earthquake epicenters of magnitude 4.0 or greater (Richter Scale) have been recorded along the fault during historic time.

The fault is designated as potentially active until more information is available for evaluation.

Bailey Fault

This fault marks the boundary between the western Santa Monica Mountains and the Oxnard Plain. It extends from the Mugu Lagoon area northerly to an apparent intersection with the Camarillo Fault near Calleguas Creek and State Highway 101. The presence of the fault is based primarily upon water well data.

No evidence of surface expression of the fault is known nor have any earthquakes been recorded as having originated on it. The fault trace is obscured by geologically young alluvium over its entire length. Available information is insufficient to conclude that the fault has not been active during Pleistocene or more recent time.

The fault is designated as potentially active until more information is available for evaluation.

Camarillo Fault

This fault extends in an east-west direction immediately south of Camarillo from Calleguas Creek to the Oxnard Air Force Base. The presence of the fault is based primarily upon the apparent abrupt uplift along the north side of the fault linear uplift of the southern portion of Camarillo.

The apparent uplift of the north side of the fault is believed to be a surface expression of the fault. The fault trace, however, is obscured by geologically young alluvium over its entire length. Available information is insufficient to conclude that the fault has not been active during Pleistocene or more recent time.

The fault is designated as potentially active until more information is available for evaluation.

Sycamore Canyon and Boney Mountain Faults

These faults are the most prominent of a series of north-east trending breaks extending from the Point Mugu and south coast area to the Thousand Oaks area. The presence of the faults is evident by surface exposures showing displacement of sedimentary and volcanic rocks of pre-Pleistocene age. Younger rocks are not known to have been displaced by these faults.

Surface evidence of displacement of sedimentary and volcanic rocks of pre-Pleistocene age indicate that the faults have been active since deposition of those rocks. Younger rocks are not known to have been displaced by them. However, no specific investigations have been reported indicating that displacement of younger deposits has not occurred. Special areas of concern would be in the Potrero, Conejo, and Hidden Valleys and the Thousand Oaks area.

The faults are designated as potentially active until more information is available for evaluation.

Oak Ridge Fault System

The Oak Ridge Fault is a steeply southerly-dipping reverse or thrust fault which extends from the Santa Susana Mountains where it has been overridden by the north-dipping Santa Susana Thrust Fault, westward along the southerly side of the Santa Clara River Valley and thence into the Oxnard Plain. The relationship of possible westerly extension of the fault to the McGrath and offshore faults is unclear and may be complex. None of the faults beyond the westerly terminus of South Mountains have surface expression nor have any been shown to cut near surface sediments. It is conceivable that past movement of these faults in the Oxnard Plain area has not resulted in surface displacements but, instead, has resulted in only broad warping or tilting of the near surface alluvial sediments.

The Oak Ridge Fault System probably contains many branching faults and is believed to be associated with one or more faults of similar trend present in the Santa Barbara Channel

west of the Oxnard Plain. The system is over 50 miles long on the mainland and may extend an equal or greater distance offshore.

The rugged, steep terrain of the north slope of South Mountain suggests that at least that portion of the Oak Ridge Fault is active. The lack of surface evidence of fault displacement in the Oxnard Plain is not necessarily indicative of past activity in the recent geologic past as surface features could easily have been obscured by fluvialite processes (erosion or deposition of alluvium). Several recorded earthquake epicenters in the offshore as well as mainland area during historic time may have been associated with the Oak Ridge Fault or others within close proximity and associated with it.

The fault system is considered active. Future information may result in portions being designated as inactive.

Ventura Foothills and Country Club Faults

The Ventura Foothills Fault has been postulated to exist along the base of the hills south of Sulfur Mountain extending from north of Saticoy westerly to the mouth of the Ventura River thence westerly an unknown distance into the Santa Barbara Channel area. The possible existence of this fault as well as the nearby Country Club Fault northerly of Montalvo is reported in "Geology, Seismicity and Environmental Impact." (1973), a special publication of the Association of Engineering Geologists.

Evidence for the existence of the Ventura Foothills Fault is based mainly upon minor faulting of Terrace deposits north of San Buenaventura and evidence of faulting from the Tidewater Oil Company corehole #5. The fault is believed to be north-dipping. The existence of the Country Club Fault is based mainly upon discontinuities of water wells located in the Saticoy vicinity.

At present, sufficient information to verify the presence of past or potential future activity of these faults is lacking.

Future studies will provide information regarding existence and potential activity of these faults. It is considered prudent, however, to acknowledge the presence of these faults and consider them as potentially active, at least until further information is available.

Red Mountain-San Cayetano-Santa Susana-San Fernando Fault System

This fault system consists of a major series of north-dipping thrust faults which extend over 150 miles from Santa Barbara County into Los Angeles County. The system is associated

with an intense zone of folded and faulted bedrock. Relationships within the system become obscure over an 8 mile wide gap between the Red Mountain and San Cayetano Faults where these north-dipping faults give way to several large, south dipping faults.

Geologic evidence that the fault system should be considered active throughout its length is shown by location of earthquake epicenters (including the San Fernando Earthquake of 1971), groundwater barriers, and displaced alluvial sediments. In addition, the unusually high fluid pressures in the Ventura and San Miguelito oil fields are believed to indicate that tectonic stress has accumulated along that section of the fault system between the Red Mountain and San Cayetano Faults. It is possible that continued build up of this stress will eventually result in sudden release, probably in the form of an earthquake resulting from movement along one of more of the faults within the Ventura County portion of the system.

Research has shown that the San Cayetano Fault has 20,000 feet of displacement several miles east of Ojai Valley. The epicenter of an earthquake of magnitude 4.0 to 4.4 (Richter Scale) was located above the San Cayetano Fault between Fillmore and Piru.

The system is considered active.

Lion Mountain-Big Canyon Faults

These faults and several others present in the 8 mile gap between the Red Mountain and San Cayetano Faults dip southerly beneath Sulfer Mountain. The general area is complexly broken and folded by faulting which may be associated with the high fluid pressures (stress) present in the Ventura Oil Field to the south.

Although the general area of these faults has not experienced earthquake activity during historic time, their position within the Red Mountain-San Cayetano-Santa Susana-San Fernando Fault System and the possible displacement of terrace deposits (Pleistocene time) indicates that they should be considered at least potentially active.

Arroyo Parida-Santa Ana Fault

This fault extends from Montecito to the Ventura River and probably along the south side of Ojai Valley. Evidence as to the direction of dip is conflicting.

Although no earthquake activity has been recorded during historic time the fault does apparently form a groundwater barrier in the alluvium beneath the Ventura River. On this basis, it

should be considered potentially active. Future information may require reclassification.

Santa Ynez Fault

This fault extends from Point Conception in Santa Barbara County, across the central portion of Ventura County, to near the east County line. It is considered to be one of the major faults in the region and is about 90 miles long. Past displacement has been about 10,000 feet of relative uplifting of the south side of the fault. The fault lies about 4 miles north of Ojai.

Left lateral displacement of streams crossing this fault has been cited as evidence for recent fault movement. Several earthquake epicenters have been located along this fault and one or two of these were in Ventura County. The strong 1927 earthquake centered west of Point Conception may have originated on the westerly, offshore extension of this fault.

This fault is considered potentially active until additional information is available for evaluation.

Faults Between the Santa Ynez and the North County Line

Several large faults occur in the mountainous area north of the Santa Ynez Fault and within Ventura County. The most significant of these faults are the Tule Creek, Munson Creek, Agua Blanca, Frazer Mountain and Big Pine Faults. Of these the more important appear to be the Pine Mountain Thrust and Big Pine Faults (9 and 16 miles north of Ojai, respectively). The Pine Mountain Thrust is north-dipping and favorably oriented for generating earthquakes in response to the north-south compressive forces which have triggered activity along such similar faults as the Malibu, San Fernando and San Cayetano.

Terrace deposits and stream channels have been offset by geologically recent movement along the Big Pine Fault. More importantly, it is reported to have ruptured the ground surface for a distance of 30 miles along its length during the northern Ventura County earthquakes of November, 1852.

Both of these faults are considered active.

San Andreas Fault

The San Andreas is the longest and most important fault in California. It transects a 4 mile section of the extreme northeast corner of the County, about 27 miles northeast of Ojai. It is the only fault within Ventura County which the

State has designated as being within a Special Studies Zone. Several Special Studies Zones have been established by the State Division of Mines and Geology along several of the major active faults within the State. Development proposed within these zones will require special site investigations prior to approval to insure that structures for human occupancy are not placed over a fault or fault branch. The State anticipates it will establish similar zones along other faults as funds become available for evaluation of potential activity.

Due to clearly established historical earthquake activity; this fault has been designated as active by the State Division of Mines and Geology. The last major earthquake generated along that portion of the fault which transects the northeast portion of the County was in 1857. The earthquake is estimated to have been on the order of magnitude 8.0 (Richter Scale) and would have caused considerable damage to structures in the southern County area had they been there. The occurrence of another such major earthquake along this fault is considered possible within the near future.

DEFINITION OF FAULT HAZARD ZONE

The fault hazard zones define a boundary where active or potentially active faults are believed to be located. These zones, based on available geologic data and the judgment of the County engineering geologist, are plotted on Hazard Plate I. Faults shown on the Fault Hazard Area Map, but not included in either the Primary or Secondary Fault Hazard Areas are presently considered inactive.

The extent of Fault Hazard Zone boundaries are controlled by the traces of potentially active faults which are based on the best data available at the time the map was compiled. However, the faults shown on the maps were not field checked during the compilation of these maps. Because available fault data are highly varied in quality and the locations of some faults are known imprecisely, the zone boundaries have been positioned at a reasonable distance (about 660 feet or an eighth of a mile) from the trace of the nearest potentially active fault. However, zone boundaries generally are more or less than 660 feet away from mapped faults because of 1) curved or multiple fault traces, 2) of the need to keep the number of turning points to a reasonable minimum, or 3) the quality of the data dictates a narrower or wider zone.

In many places the zone boundaries have been tentatively extended beyond the mapped limits of faults, such as occurs westerly of Camarillo and westerly of Saticoy. These zone extensions are considered necessary because, even though faults have not been mapped in these areas, it is considered

likely that extensions of known faults or branches of faults do extend into these areas. Future investigations or studies would be required for confirmation of any fault extensions.

The primary fault hazard zones designate areas which are believed to contain active faults. The secondary fault hazard zones include those faults for which less evidence is available concerning their potential for activity. More precise analysis requires further study. For the purpose of the Seismic Safety and Safety Elements, all primary and secondary fault hazard zones designated on Plate I should be considered equivalent to those established by the state for other faults within and outside of the County. No degree of relative potential for future surface displacement or degree of hazard is implied for the faults shown.

A fault is defined as a fracture or zone of closely associated fractures along which rocks on one side have been displaced with respect to those on the other side. Most faults are the result of repeated displacement which may have taken place suddenly and/or by slow creep. A fault zone is a zone of related faults which commonly are braided and subparallel, but may be branching and divergent. It has significant width (with respect to the scale at which the fault is being considered, portrayed, or investigated), ranging from a few feet to several miles.

A fault trace is the line formed by the intersection of a fault and the earth's surface. It is the representation of a fault as depicted on a map.

Any fault considered to have been active during Quaternary time (last 3,000,000 years) - on the basis of evidence of surface displacement - is considered to be potentially active. An exception is a Quaternary fault which is determined, from direct evidence, to have become inactive before Holocene time (last 11,000 years). Such a fault is presumed to be essentially inactive and has been omitted from the map in most cases. Although faults shown on the maps may have been active during any part of, or throughout, Quaternary time, evidence for the recency of displacement is incompletely preserved and often is equivocal. In contrast, the State Mining and Geology Board, in their Policies and Criteria (adopted November 21, 1973), has defined any fault which has had surface displacement within Holocene time as "active and hence as constituting a potential hazard."

The following geologic time scale is provided for reference and perspective:

ILLUSTRATION 2.2 GEOLOGIC TIME SCALE
(abbreviated)

Geologic Age			Years before present (estimated)	
Era	Period	Epoch		
CENOZOIC	QUATERNARY	"Historic"	200	Faults defined as <u>active</u> by Policies & Criteria of the State Mining & Geology Board.
		HOLOCENE	11,000	
		PLEISTOCENE		
	TERTIARY		2,000,000 - 3,000,000	Faults defined as <u>potentially active</u> for the purpose of delineating special studies zones.
		PLIOCENE		
		pre-PLIOCENE	7,000,000 - 10,000,000	
pre-CENOZOIC time			65,000,000	Source: State Mining and Geology Board
Beginning of geologic time			4,600,000,000	

Uses and Limitations of the Hazard Zones

The best use of the fault zones is to define those areas within the zone as areas where special studies would be required prior to building structures for human occupancy. Such a criteria may require a developer or builder to evaluate specific sites within the zone to determine if a potential hazard from any fault whether heretofore recognized or not, exists with regard to proposed structures and their occupants.

Such studies should be required both for Primary and Secondary Fault zones. The latter should be included since future studies of these secondary zones could result in the redesignation of some of these to primary fault zones.

Users of the map should be fully aware that the zones are delineated to define those areas within which special studies may be required prior to building structures for human occupancy. Traces of potentially active faults are shown on the

maps mainly to justify the locations of zone boundaries. These fault traces are plotted as accurately as the sources of data permit; yet the plots are not sufficiently accurate to be used as the basis for set-back requirements.

Potentially active faults have been identified in a broad sense, although the evidence for the potential activity of some faults may be only weak or indirect.

The fault information shown on the map is not sufficient to meet the requirement for special studies. The onus is on the local governmental units to require the developer to evaluate specific sites within the special studies zones to determine if a potential hazard from any fault, whether heretofore recognized or not, exists with regard to proposed structures and their occupants.

Secondary Fault Hazard Zones designate areas which may contain faults which should be considered potentially active. Future studies as well as experience could result in redesignation of some of these areas to Primary Fault Hazard Zones. Special studies, as required for Primary Fault Hazard Zones, should therefore continue to be required prior to approval of residential or other proposed permanent development within the Secondary Fault Hazard Zones.

Faults shown on the Fault Hazard Area map but not included in either the Primary or Secondary Fault Hazard Areas are presently considered inactive. In general, they are not considered to be associated with the major, regional, potentially active fault zone trends. Special studies should, however, continue to be made of such faults prior to approval of any individual residential or other permanent developments which may be proposed over or in the near vicinity of any known faults.

Special Studies Zones

In 1972 the California State Legislature enacted the Alquist-Priolo Geologic Hazard Zones Act. Pursuant to this act the "State geologist shall delineate . . . special studies zones to encompass all potentially and recently active traces of the San Andreas, Calaveras, Hayward, and San Jacinto Faults, and such other faults . . . as to constitute a potential hazard to structures from surface faulting or fault creep." (Alquist-Priolo Act).

The extreme northeast corner of Ventura County lies within the special study zone established for the San Andreas Fault transecting that area. It is anticipated that the State will, after appropriate evaluation, establish other such special studies zones along other faults transecting the county.

The intent of the zone is to provide for public safety from the hazard of fault rupture by avoiding, to the extent possible, the construction of structures for human occupancy astride hazardous faults. However, the precise location and identification of hazardous faults within or near a zone of potentially active faults can be determined only through detailed geologic investigations. Therefore the State Mining and Geology Board has adopted policies and criteria for the implementation of these zones.

The complete text of the Policies and Criteria is in appendix B. Its most significant criteria is that no structure may be built across the trace of an active fault. Furthermore, the area within fifty feet of an active fault shall be assumed to be underlain by active branches and therefore, before any structure can be built within the zone, a geologic investigation and submission of a report by a geologist registered by the State of California are required. In addition, any city or county may require more restrictive policies.

NATURE OF INFORMATION

The geologic information relating to the location of faults and their potential for activity is based largely upon past regional geologic studies conducted by universities and petroleum geologists, as well as information compiled by the State Division of Mines and Geology and the County Department of Public Works. The most recent geologic information used was that covering the south half of the County which is contained in a report entitled "Geology and Mineral Resources Study of Southern Ventura County," Preliminary Report 14, 1973, prepared by the Division of Mines and Geology in cooperation with the County of Ventura Department of Public Works.

The evaluative system utilized in estimating the potential or past activity of individual faults and fault systems is discussed under General Inventory of the Hazard. The basis and method of designation of the Fault Hazard Zones is similar to that used by the State Division of Mines and Geology in establishing the Special Study Zones along active and potentially active faults within the State (see FAULT HAZARD ZONES section.)

The current cooperative Geologic Hazards Investigation being conducted by the State Division of Mines and Geology for the Ventura County area will provide additional necessary information for future up dating of the Seismic Safety and Safety Elements. The State investigation will be especially useful for improving our knowledge of those faults and fault systems which have been herein designated as potentially active (Secondary Fault Zones). The investigation may include study of

the following faults and fault systems: Simi-Santa Rosa, Springville, Camarillo, Oak Ridge, Ventura Foothills, Country Club, Bailey, Arroyo Parida-Santa Ana and the Big Pine.

GENERAL MANAGEMENT RESPONSIBILITY

Investigation

Research and experience dealing with the nature and mechanism of faults and fault activity is being conducted by various Federal and State agencies as well as by universities and professional organizations. Much of this work is being conducted on a statewide basis, however, indirect benefit to Ventura County will be gained through developed technology.

The State Division of Mines and Geology is currently investigating the extent of the hazard to Ventura County as part of the cooperative Geologic Hazards Investigation scheduled for completion by July of 1975.

Additional investigation is being conducted on a continuing basis by:

Private Geologic Consultants who provide original information during investigations for private developments.

Ventura County Department of Public Works which:

- a) Provides review and evaluation of Geologic and Soils and Foundation Engineering reports prepared for private projects within the unincorporated area and for the Cities of Camarillo, Simi Valley and Santa Paula.
- b) Performs Geologic and Soils Engineering investigations for County projects such as roads and flood control facilities.
- c) Coordinates, evaluates, and compiles geologic information derived from public and private investigations within the unincorporated areas and for the Cities of Camarillo, Simi Valley and Santa Paula.

Warning

Presently there is no way to prevent or accurately predict when an earthquake and surface displacement is apt to occur

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along a given fault. The state-of-the-art is such that at best only the recency of past activity can be determined along some faults. In addition, in some cases, regional studies can indicate those systems of faults which may be potentially most active. In the southern California area, those faults which have general east-west trends or are associated with the northwesterly trending San Andreas Fault are considered to be potentially the most active. There are indications that earthquake prediction will be possible in some areas of the United States in the near future. It is not known whether this will be one of those areas. However, there are serious social and economic problems with predicting earthquakes that must be evaluated before these predictions can be utilized, when they are perfected. The National Science Foundation is presently instituting studies on these problems.

Alleviation

Regulation of public and private land development within both incorporated and unincorporated areas is administered by:

City and County Departments of
Planning
Public Works
Building & Safety
City Councils
Board of Supervisors

Enforcement of the Uniform Building Code and City and County regulations and policies can be effected by the above agencies through requirement of review of proposed land use and evaluation of investigations and engineering studies for private development of public projects. Such reviews and evaluations can be performed by qualified geologic and soils engineering staff or by retention of consultants. Effective control of the Fault Hazard can only be achieved through knowledge of the location and potential for activity of faults and implementation of development controls within the hazard zones.

Since alleviation of the hazard is largely accomplished through land use controls, the agencies, departments and legislative bodies making land use decisions have the primary responsibility for alleviating the hazard. City and County Planning departments can utilize available hazard information to avoid improper land uses. Decisions concerning adoption of these recommendations rest ultimately with the Planning Commissions, City Councils and the Board of Supervisors. Other bodies making land use decisions include Port Districts and redevelopment agencies.

Alleviation of existing hazards can be effected by removal of structures located over, or strengthening structures in

hazardous proximity to, potentially active faults. Determination of whether structures are hazardously located would require detailed investigation of geologic conditions and of the potential for activity along any faults found.

LOCAL DISCUSSION

LOCAL INVENTORY OF THE HAZARD

The County of Ventura lies within the seismically active region of Southern California and, as characteristic of the region in general, is transected by many faults. Many of the faults are associated with major fault systems extending beyond County boundaries. Several of these faults and fault systems are considered to be active but a great deal of additional information must be assembled to determine the potential for, as well as the nature of, activity of most of the faults including those presently considered to be active.

The present level of knowledge of the recency of surface or near surface movement along the faults within Ventura County is not sufficient on which to base a firm determination of the "degree" of activity of most of these features. There is some evidence that some of the known faults have displaced at least late Quaternary terrace sediments, indicating possible movement as recent as 11,000 years ago. This is primary basis for designating the most recently active faults, as these could have the higher potential of future movement.

The primary hazard zones contain faults which have relatively sound geologic evidence of movement within historic or holocene (the last 11,000 years) times. There are three primary fault hazard zones in the south half of the county. The San Cayetano Fault Zone extends from Los Angeles County to Ojai, north of the Santa Clara River Valley. The Oak Ridge Fault is located at the base of the scarp on the south side of the valley. The third primary zone surrounds the Red Mountain Fault and its associated faults from the Ventura River to the border with Santa Barbara County. (See Hazard Plate I).

The faults for which there is some preliminary evidence for Holocene or historic movement, or which, due to their location, provide a significant threat to life and property if movement should occur, are included in the Secondary Fault Hazard Zones. These zones, of which there are a large number in the populated south half, are areas that will be specially studied during the cooperative hazards study with the State this year, to determine if they are active or inactive. As shown on Hazards Plate I, there are mainly four groups of faults thus designated.

First, near Ojai there is the Santa Ana - Lion Canyon system, west of the San Cayetano System. Second, from Simi Valley through Camarillo and Oxnard is the Simi - Santa Rosa Fault System and other nearby faults. Third, the Sycamore Canyon -

Boney Mountain System runs from Point Mugu to Thousand Oaks and the Bailey Fault is a splinter connecting to Camarillo. The last area is the Foothill-Country Club Fault System in San Buenaventura. In addition, the other minor faults can be mentioned. The Malibu Coast Fault is just offshore of the southern tip of the County's and the offshore Hueneme Canyon fault whose hazard zone enters the City of Port Hueneme.

There are two faults designated as primary zones in the North Half of the County. The Big Pine Fault, which bisects Lockwood Valley, is considered active as it was the source of a major earthquake in 1852. The San Andreas Fault, which barely crosses the northeast corner of the County, is also considered active because it was the source of a ± 8 magnitude earthquake in 1857. The rest of the faults in the north half are in Secondary Fault Hazard Zones.

Any of the fault designations within the County are subject to change as further evidence is received, either indicating clearer proof of potential for activity or providing convincing geologic evidence of inactivity.

LOCAL RESOURCES AFFECTED BY THE HAZARD

The unincorporated areas of the County may be substantially impacted by movement along faults. The effects are summarized in the accompanying table, following the text. The Arroyo Párida - Santa Ana Fault zone extends from the Lion Mountain fault zone, through portions of Meiners Oaks to the Santa Barbara County Line, cutting portions of State Highways 150 and 33. Two schools lie in the fault zone as does the water transmission line from Lake Casitas and Ventura to the Ojai area, which also crosses the fault zone. Sewer mains in the Meiners Oaks area and in Villanova Road are also located in the fault zone.

The Red Mountain - Padre Juan fault zone extends from Highway 3 near Cañada Larga Road to the north coastal area of the County into the Pacific Ocean and Santa Barbara County. The coastal communities of La Conchita and Solimar are located in this zone, as is a county fire station on Highway 101 very close to or on the Padre Juan fault. Power transmission lines going to Santa Barbara County enter this fault zone as do many major gas lines, water transmission pipes and sewer mains.

North of the Red Mountain - Padre Juan fault zone extends another secondary fault zone encompassing a portion of Highway 33, power transmission lines to Santa Barbara County and their

associated sub-stations in the area, and gas mains, water transmission lines and sewer mains on Ventura Avenue to Ojai.

The Lion Mountain fault zone is located between Lake Casitas and the San Cayetano fault zone east of Ojai. This zone contains the major portion of the Oak View community including Oak View and Arnaz schools and a county fire station. Major electrical transmission lines, gas mains, water transmission lines, and sewer mains between Oak View and Ojai transverse this zone.

The San Cayetano - Del Valle fault zone is located between the Los Angeles County Line and east of Ojai, entering into portions of the Piru Community and north of Fillmore and Santa Paula. Summit and Piru schools are located in the fault zone as well as a fire station near Summit School on Highway 150. The State Fish Hatchery east of Fillmore is also within this primary hazard zone. Main power lines from Los Angeles County to the Santa Clara Transmission Station enter into this fault as well as gas mains, water transmission lines, and sewer mains east of Ojai and Fillmore which are in the hazard zone portions of Piru.

The Canyon - Sisar fault zone extends west of the San Cayetano fault zone, south of Highway 150. Because it is located in hilly portions of the County, no major resources are effected.

The Culbertson fault zone and another unnamed fault zone north of it also do not impact major resources. Located north of Santa Paula and east of Highway 150, the area does not contain many resources.

Few major resources are located in the Eureka Canyon - Santa Susan fault zone, which is between the Oak Ridge fault zone and the Los Angeles County Line. However, major electrical transmission lines from Los Angeles County to Moorpark and a 34" gas main does penetrate the fault zone.

The Simi fault zone extends from the Los Angeles County Line, north of Simi Valley and ends up in the Virginia Colony area. A portion of a housing development is located within the fault zone as well as major power lines, gas mains north of Simi Valley, a water transmission line to Moorpark and a sewer main west of Simi Valley. Also, the Simi Valley Adventist Hospital is located within the fault zone.

No major resources are located within the Cañada de la Brea fault zone, which reaches out from the Simi fault. However, power transmission lines, an 8" gas main and a sewer line do enter into an extension fault zone of the Cañada de la Brea fault.

Another fault zone is located east of Moorpark on a north-south orientation. A portion of the Virginia Colony area

is located in the fault zone, besides major power, gas, water, and sewer lines.

Another fault exists between Moorpark and Fillmore with Highway 23 bisecting the zone. Besides the roadway, only a 6" gas line is located within the fault zone.

The Sycamore Canyon fault rises from the Pacific Ocean near Mugu Lagoon, through the Santa Monica Mountains to Newbury Park, past the 101 Freeway into Thousand Oaks. Going through the Newbury Park area, four schools plus several utility facilities such as power lines to Lake Sherwood; gas mains near the 101 Freeway and Lynn Road; water transmission lines; and sewer mains are located in the fault zone.

A linament of the Sycamore Canyon fault is located primarily in Thousand Oaks, beyond the area of concern for the element.

Extension of fault zones occur east and west of the Sycamore fault zone. The western zone extends from near Potrero Road; bisects Reino and Wendy Drive; follows the 101 Freeway near Borchard Road, and finally joins the Sycamore fault east of Ventu Park Road. Besides portions of the residential area of the Newbury Park area, Manzanita School and a major water and sewer main are located within the fault zone.

The eastern extension breaks from the Sycamore Canyon fault south of Borchard Road, touching Ventu Park Road and continuing on past the 101 Freeway further into Thousand Oaks. Besides the general urban area which is located within the fault, there appears no other major resources located within the area.

No major resources except for a power line to the Thousand Oaks sub-station appear to lie in the Boney Mountain fault zone, which is located south of the eastern extension of the Sycamore Canyon fault.

The Bailey fault zone extends from Mugu Lagoon towards Camarillo and intersects with the Santa Rosa fault zone east of that city. Camarillo High School along with major power lines from Ormand Beach power plant, gas lines, water transmission pipes, the Camarillo State sewage plant and sewage mains east of Camarillo are situated within the fault zone.

An extension fault zone is located due east of the Bailey fault through Camarillo State Hospital into the surrounding hills. The hospital lies directly in the fault zone.

The Santa Rosa fault zone starts east of the Springville fault at Las Posas Road, following the Santa Rosa Valley until meeting the Simi fault zone near Highway 118. Within

the unincorporated areas, major power lines from Ormand Beach power plant as well as gas and water mains and St. John's Seminary are located.

An extension of the Santa Rosa fault zone is located north of its eastern portion terminating at the Simi fault zone. No major resources are situated within the zone.

The Springville fault zone extends north of Camarillo, through Oxnard to the Pacific Ocean. Near Camarillo, two schools are located within the fault zone as well as the Mandalay Power plant in Oxnard. Also, major sewer, water, gas and electric lines enter into the fault zone.

The Oakridge fault basically follows the Santa Clara river bed with a southern deviation near Fillmore. Due to this situation only utilities such as power, water, gas and sewer lines are major resources which enter into the hazard zone.

An extension of the Oakridge fault is located almost entirely in the City of San Buenaventura and consumes most of that city's area. Thus no major resources in the unincorporated areas are impacted by this fault zone.

Finding: All transmission lines from power sources cross or enter into at least one fault zone.

Illustration 2.3
Resources Affected by
Hazard Zone

	ZONES	Arroyo Parida Santa Ana	Red Mountain Fault	Lion Mountain Fault	San Cayetano Del Valle	Big Canyon-Sisar Faults
SINGLE-FAMILY			X	X	X	
MULTI-FAMILY						
SCHOOLS	SANTA ANA VILLANOVA			OAKVIEW ARINAZ	SUMMIT PIRU	
HOSPITALS						
CITY HALLS						
POLICE STATIONS						
FIRE STATIONS			X	X	X	
SEWER	X	X	X			
WATER	X	X	X			
GAS		X	X			
ELECTRICITY		X	X			
LARGE STRUCTURES						
MAJOR ROADS	X	X	X	X		
OTHER					X	

	ZONES				
	Fault East of Moorpark	Fault North of Moorpark	Sycamore Canyon Fault	Extension Sycamore Fault T.O.	West Side Fault of Sycamore Canyon Fault
SINGLE-FAMILY	X				
MULTI-FAMILY					
SCHOOLS			ACACIA ST. PASCAL BAYLON FREEDWOOD BANNON		MANZANITA
HOSPITALS					
CITY HALLS					
POLICE STATIONS					
FIRE STATIONS					
SEWER	X		X		X
WATER			X		X
GAS		X	X		
ELECTRICITY	X		X	X	
LARGE STRUCTURES					
MAJOR ROADS			X		
OTHER					

	ZONES				
	Culbertson Fault	Eureka Canyon- Santa Susana Fault	Fault Zone No. of Culbertson Fault	Simi Fault	Cañada de la Brea
SINGLE-FAMILY				X	
MULTI-FAMILY					
SCHOOLS					
HOSPITALS				SIMI VALLEY ADVENTIST	
CITY HALLS					
POLICE STATIONS					
FIRE STATIONS					
SEWER				X	
WATER					
GAS		X		X	
ELECTRICITY		X		X	
LARGE STRUCTURES					
MAJOR ROADS					
OTHER					

	ZONES				
	Linament of Sycamore Cyn. Fault all in T.O.				
	Boney Mountain Fault				
	Bailey Fault				
	Fault Near Camarillo State Hospital				
	Santa Rosa Fault				
SINGLE-FAMILY					
MULTI-FAMILY					
SCHOOLS			CAMARILLO HIGH SCH.		SANT JOHN'S
HOSPITALS			CAMARILLO STATE HOSPITAL		
CITY HALLS					
POLICE STATIONS					
FIRE STATIONS					
SEWER			X		
WATER					X
GAS	X		X	X	X
ELECTRICITY	X	X	X		X
LARGE STRUCTURES					X
MAJOR ROADS					
OTHER					X

	ZONES				
	Extension of Santa Rosa Fault	Spring Ville Fault	Oak Ridge	Oak Ridge Extension	Camarillo Fault
SINGLE-FAMILY					
MULTI-FAMILY					
SCHOOLS		CAMARILLO HEIGHTS SAINT COLUMBIA			
HOSPITALS					
CITY HALLS					
POLICE STATIONS					
FIRE STATIONS			X		
SEWER		X	X	X	X
WATER		X		X	
GAS		X	X		
ELECTRICITY		X	X		X
LARGE STRUCTURES					
MAJOR ROADS					
OTHER		X			X

FINDINGS

PROBABILITY OF OCCURRENCE

Available geologic information indicates that the potential for the occurrence of surface displacement along one or more of the major east-west trending faults within the County and within the life of existing structures is high compared to the potential hazard Statewide. Major development along most of the east-west faults within the County should be carefully considered until such time as adequate information is available to conclude that such faults are not active or potentially active.

SEVERITY OF THE HAZARD

Although experience has shown that destruction of structures placed over faults along which sudden surface displacement occurs is nearly total, historically only on one occasion has surface displacement significantly affected development (San Fernando Earthquake of 1971). Although this hazard is considered real within the County, the effect of the hazard is low compared to the likelihood of greater losses which could occur as a result of strong earthquake shaking.

RESOURCES AFFECTED

In the event of surface displacement along a fault transecting one of the urbanized or industrialized areas of the County, loss of life and property damage in the unincorporated and incorporated areas could be significant depending upon where the displacement was located. Large areas of the County are undeveloped including, in general, much of the area in which faults have been mapped. Further development along faults will increase the likelihood that some day fault displacement could affect development.

Much of the existing land development occurred several years ago at a time when the full potential danger of concealed or obscure faults was unrecognized and, therefore, little subsurface investigation of geologic conditions was conducted. The full potential danger of surface fault displacement was unknown until the occurrence of the San Fernando Earthquake of 1971. As a result, little is known of the recency of past movement along most of the faults within the County or whether any related fault branches may be present. Several recent investigations for private development in the vicinity of some of the faults has indicated no fault disturbance of near surface earth materials. Future such investigations could, however, reveal that some segments, branches, or extensions of faults within the zones are active.

NATURE OF THE INFORMATION

Present information is not considered sufficiently accurate to warrant special investigation for most existing development. Consideration should, however, be given to reconfirming the safety of important, vital or emergency facilities including public structures and those where large numbers of people may gather where they are over or in the near vicinity of known faults. Future, more detailed information on fault locations may indicate that further evaluation of some existing structures or facilities could be warranted.

Determination of the exact location of faults or whether any other faults pass beneath or in the near vicinity of an existing, important structure would require detailed site investigation. Such analysis, however, was not within the scope of this study.

OTHER FINDINGS

Present controls in regard to land development include the State Subdivision Map Act, as well as various county ordinances and policies, primarily the:

1. Subdivision Ordinance
2. Grading Ordinance
3. Building Regulations
4. Land Development Manual

The present controls are considered to be adequate for determination of the feasibility of proposed development in regard to determination of geologic conditions and incorporation of appropriate design safeguards. Knowledge in regard to geology and design considerations is, however, constantly improving through research and experience and it should be anticipated that present requirements will be subject to improvement.

Consideration should be given to evaluating geologic conditions for important or vital buildings and facilities within hazard zones for which such determinations have not been made. In many cases this may not require extensive investigations to confirm that near surface faults do not pass beneath or are in hazardous proximity to structures. Subsurface investigation, however, may be necessary for such structures where additional information is required to determine the potential activity of faults. Structures which could be considered for evaluation include hospitals, rest homes, churches, large commercial buildings, important industrial structures, schools, residential or commercial buildings over two stories in height and critical utility facilities.

Additional information concerning the location and degree of activity of faults will be provided by the current cooperative

Geologic Hazards Investigation (of Ventura County) being conducted by the State Division of Mines and Geology. In addition, private investigations for proposed projects will also continue to provide useful information.

Present procedures of evaluating proposed projects are considered adequate and in keeping with present State laws and policies in regard to geologic considerations and incorporation of design safeguards for most land development. Land use planning, however, can be greatly improved in effectiveness through a greater knowledge of fault hazards - their location, nature and effects.

OPTIONS

1. Consider all faults (whether zoned or not) shown on Hazards Plate I as potentially hazardous unless detailed seismic-geologic investigation confirms the contrary.
2. Allow no buildings or other structures whose failure could result in damage to life and property to be placed over any fault lines unless detailed geologic seismic investigation proves that the fault is inactive (has not experienced displacement within about the last 11,000 years).
3. Encourage performance of regional studies by qualified Federal and State agencies such as the U.S. Geological Survey and the State Division of Mines and Geology.
4. Encourage and participate in cooperative studies with the above agencies.
5. If necessary, retain private consultants for more detailed determination and study of potential hazards.
6. Adopt current Uniform Building Code and the additional provisions of the County Subdivision Ordinance, Building Regulations and the Land Development Manual or equivalent requirements for all land development.
7. Provide adequate enforcement of the aforementioned requirements by requiring that each proposal for land development and reports and plans submitted be reviewed by qualified personnel registered and certified by the State such as professional engineers, soils engineers and engineering geologists. Adequate enforcement can be achieved through establishing qualified staff or retaining private consultant or County services on an as-needed basis.
8. Adopt current investigation guidelines for proposed land development within the Primary or Secondary Fault Hazard Zones and for all major projects such as those published by the Structural Engineers Association of Southern California (Appendix D).
9. Require geologic-seismic investigation for all major projects such as multi-story buildings, industrial installations and buildings, large commercial buildings, large utility and storage facilities, and major trunk lines proposed anywhere within the County or Cities.

10. Consider mitigating measures within the hazard zones, such as modification of existing or proposed structures and facilities and improvement of emergency preparedness.
11. Allow no buildings to be constructed over active faults. Where a fault rupture area is not under public ownership, no more than very low, single family residential density should be considered. Agricultural use of land could be encouraged.
12. Consider the need for evaluating geologic conditions for important or vital buildings and facilities within hazard zones for which such determinations have not been made. Structures which could be considered for evaluation include hospitals, rest homes, churches, large commercial buildings, important industrial structures, schools, residential or commercial buildings over two stories in height or buildings of unusual construction over one story designed for human occupancy, utility facilities and other vital or critical structures.

Administration of Fault Hazard Zones

13. In the interest of consistency and standardization, the Specific Criteria Section (modified) of the Policies and Criteria of the State Mining and Geology Board and the State Geologist's Explanation of the Special Studies Zones Maps (modified) should be adopted for administration of these zones and are as follows:
 - A. No structure for human occupancy shall be permitted to be placed across the tract of an active fault. Furthermore, the area within fifty (50) feet of an active fault shall be assumed to be underlain by active branches of that fault unless and until proven otherwise by an appropriate geologic investigation and submission of a report by a geologist registered in the State of California. This 50-foot standard is intended to represent minimum criteria only for all structures. Certain essential or critical structures, such as high-rise buildings, hospitals, and schools should be subject to more restrictive criteria at the discretion of cities and county.
 - B. Application for all real estate developments and structures for human occupancy within fault hazard zones shall be accompanied by a geologic report prepared by a geologist registered in the State of California, and directed to the problem of potential surface fault displacement through

the site unless studies are waived pursuant to Section 2623 (State Code).

- C. Requirements for geologic reports may be satisfied for a single 1 or 2 family residence if, in the judgement of technically qualified city or county personnel, sufficient information regarding the site is available from previous studies in the same area.
- D. Technically qualified personnel within or retained by each city or county must evaluate the geologic and engineering reports required herein and advise the body having jurisdiction and authority.
- E. Cities and county may establish policies and criteria which are more restrictive than those established herein. In particular, comprehensive geologic and engineering studies should be required for any "critical" or "essential" structure as previously defined whether or not it is located within a fault hazard zone.
- F. Construction should not occur across the mapped traces of faults. Where it is inevitable that such construction as roads, streets, highways, utility lines, etc., must cross faults, it is important that the possibility of fault movement should be considered in their design. Critical facilities, such as hospitals, schools, utility structures and communication centers should not be planned within Primary Fault Zones. Those that may presently be in Primary Fault Hazard Zones should be replaced as soon as possible or confirmed to be safely located.
- G. Those facilities which are not critical but which do have high occupancy potential such as theatres, churches, major markets, apartment complexes, etc., should not be planned within Primary Fault Hazard Zones. Those that may presently be in Primary Fault Hazard Zones should be replaced as soon as possible or confirmed to be safely located.
- H. Unless entire Primary Fault Hazard Zones were to become open space, which may not be feasible, low density, well-built, timber construction homes are an acceptable planned use within the area. However, since any construction in fault corridors presents some additional hazard to life, and certainly may result in considerable property loss, it would be best if these areas could be devoted to open space of some sort.

- I. Important facilities must be kept off areas where ground ruptures and potential ground ruptures are located. When such facilities must be located in those areas, provisions must be made to accommodate the expected movement.
- J. Non-critical facilities should be kept off actual breaks but could be located adjacent to them if compensation is made in the construction for the fault movement.
- K. In the future, when public facilities are built within or near a Primary Fault Hazard Zone, justification should be included as to why the public facilities were deemed essential for the public welfare. Similarly, any existing public facilities in such hazardous areas should be reviewed and official statements made as to why they must continue to exist in these areas.
- L. As used herein the following definitions apply:
 - 1. A "structure for human occupancy" is one that is regularly, habitually or primarily occupied by humans.
 - 2. An engineering geologist certified in the State of California is deemed to be technically qualified to evaluate geologic reports to be used in the design of civil works.
 - 3. Any engineer registered in the State of California in the appropriate specialty is deemed to be technically qualified to evaluate engineering reports in that specialty.

NOTE: Model ordinance for implementation of Special Studies Zones has been developed by the State Division of Mines and Geology.

EARTHQUAKES & GROUND SHAKING

Oft the teeming earth
Is with a kind of colic pinched and vex'd
By the imprisoning of unruly wind
Within her womb; which for enlargement striving
Shakes the bedlam earth and topples down
Steeple and moss-grown towers.

Shakespeare
HENRY IV

GENERAL DISCUSSION

GENERAL DESCRIPTION

By far the greatest damage done by an earthquake is caused by the ground shaking, not the fault displacement. This section, therefore, is the companion section to the fault displacement hazard section. One of the very serious side effects of ground shaking is liquefaction, it is also covered as a separate hazard.

The probability of an earthquake is determined by a number of factors but basically by the location of active faults to an area and the tensional and compressional forces exerted against these faults.

California is interlaced with hundreds of active faults. The most important system is the San Andreas Fault which extends from south of Los Angeles to north of San Francisco. The main branch of this fault runs through the extreme northeast corner of Ventura County. This fault has been responsible for at least two major earthquakes; the San Francisco earthquake of 1906 and the Fort Tejon earthquake of 1857. The earthquake of 1857 is reported to have caused severe shaking in the, then undeveloped, southern portion of Ventura County.

In addition to the forces causing horizontal movement such as that predominant along the San Andreas Fault, Ventura County and portions of adjacent areas are subject to compressional forces acting in north-south directions. These latter forces tend to compress or try to shorten the distance from the San Andreas Fault south to the coast. The San Fernando Earthquake of 1971, resulting in the thrusting of the southern margin of the San Gabriel Mountains several feet southward over the north margin of the San Fernando Valley, was caused by these compressional forces. Several faults in Ventura County have been formed by and are related to these same forces (See Illustration 3.1). These fault systems are described in the Fault Displacement Hazard section.

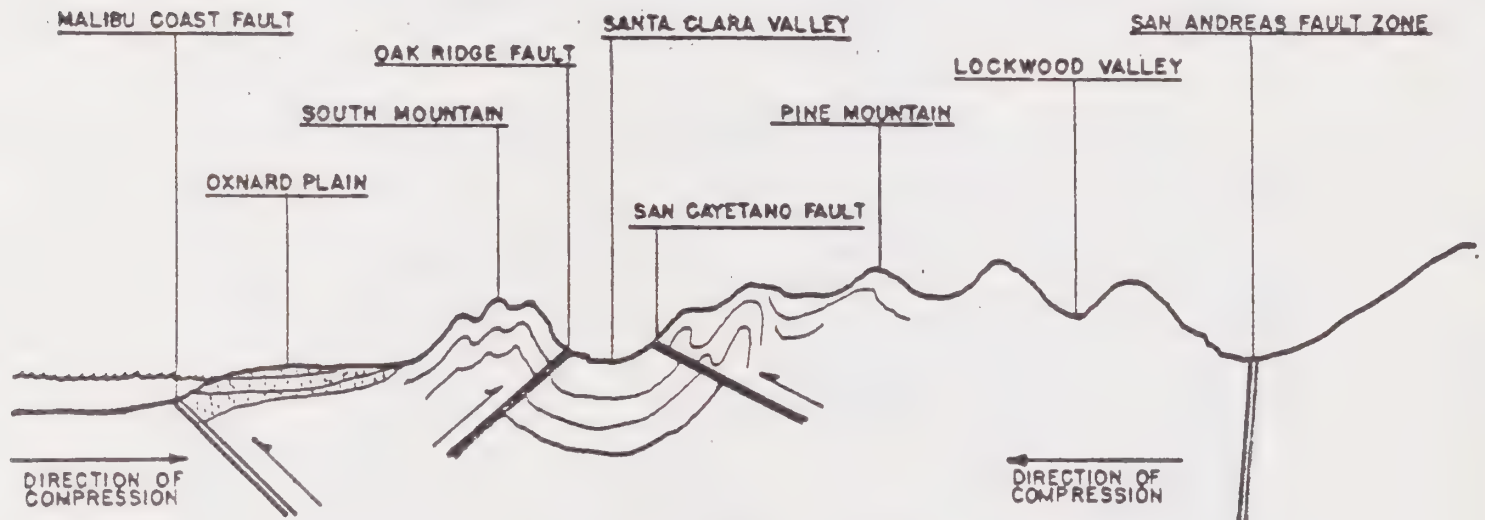
When an earthquake occurs, the break along the fault plane begins in a small area and rapidly propagates out along the fault planes. The point of first release of stress located below the earth's surface on the fault plane is called the earthquake focus. The point at the earth's surface vertically above the focus is the epicenter.

When a fault breaks, all of the accumulated strain energy is released as seismic waves. These waves travel

outward in all directions from the earthquake focus. Seismograms (records of earthquake motion) indicate that several kinds of motions are created by the passage of seismic waves. These motions can be classified as: Longitudinal Waves, Shear Waves, Rayleigh Waves, and Love Waves. Illustration 3.1 is a summary of the names and properties of the various types of seismic waves.

Illustration 3.1

A simplified north-south cross section showing the relationship of thrust faulting to presently active compressional forces.



SOURCE: Ventura County Public Works

Each of these waves has different types and directions of movement. Each can affect buildings slightly differently depending on many diverse variables. The combined effect of these waves makes up the ground shaking component of an earthquake.

In general, research of many past earthquakes indicates that the intensity of ground shaking at any given location during an earthquake is a function of several factors including:

1. Magnitude of the earthquake
2. Distance from the center
3. Depth at which the earthquake was generated
4. Type of ground motion
5. Geologic structure
6. Type of ground

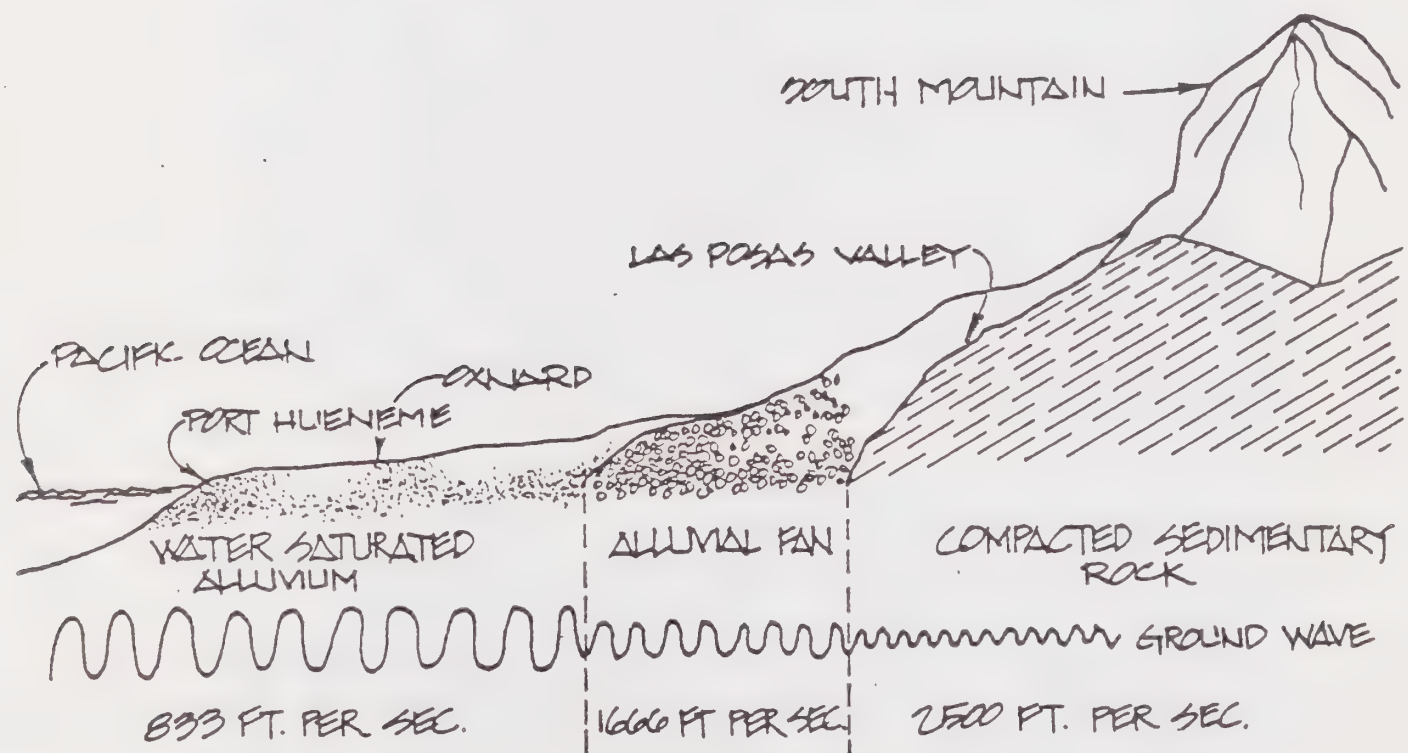
Of these, the only variable which can be assessed very accurately in advance is the type of ground. Determination of ground response (ground wave motion) can

Illustration 3.2

NAMES AND PROPERTIES OF SEISMIC WAVES			
Particle Motion Created by Pas- sage of Wave	Synonymous Names of Waves	Standard Letter Desig- nation in Seismology	Names Based on Travel Paths in Earth
Oscillation along lines in direction of wave travel	Longitudinal waves Compressional waves Push-pull waves Sound waves	P (for Primary)	Body waves
Oscillation along lines at right angles to direc- tion of wave travel	Shear waves Transverse waves Shake waves	S (for Secondary)	
Around in circles lying in vertical planes; in same direction as wave advance under troughs, in op- posite direction under crests	Rayleigh waves	L (for Large)	Surface waves
Oscillation at right angles to direction of wave travel along lines lying in hori- zontal planes	Love waves		

Source: Longwell and Others, 1969, p. 432.

Illustration 3.3 Change in speed of ground wave as it enters different materials, with a concurrent increase in amplitude.



be estimated based largely upon existing earthquake records, though only for a predicted location and magnitude of an earthquake.

The intensity of ground shaking during an earthquake depends in large part on geologic foundation conditions, i.e., the thickness and physical properties of the materials comprising the upper several hundred feet beneath the area. In general, the greatest amplitudes and longest durations of ground shaking usually occur on thick, water-saturated, unconsolidated alluvial sediments. Recent studies of groundmotion in San Francisco generated by underground nuclear explosions in Nevada indicated that the peak groundmotion velocities were as much as 10 times larger on soils adjacent to the bay than on nearby bed-rock.

Illustration 3.3 is a diagram of the area from South Mountain near Fillmore to Port Hueneme which shows the slowing down of the ground wave as it passes from consolidated sedimentary rocks on South Mountain to the alluvial fan materials of the Las Posas Valley along with a corresponding increase in wave amplitude. An increase in wave amplitude generally means an increase in intensity of ground shaking. There is even a more marked decrease in speed and increase in amplitude between the alluvial fan materials of the Las Posas Valley and the water saturated sediments of the Oxnard Plain.

Two separate indexes, or scales are commonly used in the United States in describing seismic or earthquake disturbances. The qualitative rating of the degree of earthquake shaking based upon feeling and visual observation is indicated by an intensity scale. The size or energy release of earthquakes is measured by a magnitude scale.

Measurement of the radiated energy released by an earthquake was originally proposed by C.F. Richter in 1932 and utilizes a system of tables and charts to deduce from seismological instruments a method of measuring the magnitude of an earthquake. The magnitude assigns a number to the calculated energy release, this system can rank earthquakes and compare them one to the other. By this method, an earthquake is rated independently of the place of observation.

The magnitude is the logarithm (base 10) of the maximum amplitude of a seismogram referred to a distance of 100 kilometers (62 miles) from the epicenter. Under this system, an increase of one unit in magnitude is equal to 32 times the next lower degree of energy release. Thus an earthquake of magnitude 7 represents about 32 times as much energy release as one of magnitude 6;

magnitude 8 represents 32 times the energy of magnitude 7 and, therefore, about (32×32) 1000 times the energy of magnitude 6.

The other index is much more of a reflection of the damage caused by ground shaking as it measures effects. It varies from place to place, not necessarily in direct relationship to the distance from the earthquake. The intensity is more or less independent of the magnitude.

The scale used to measure the intensity of an earthquake is the Modified Mercalli Scale with intensities ranging from I to XII (See Illustration 3.4). The scale is a description of the physical effects of earthquakes. The lowest intensity ratings are based on human reactions, such as "felt indoors by few." The highest intensities are measured by geologic effects, such as "broad fissures in wet ground, numerous and extensive landslides, and major surface faulting." The middle intensity range is based largely on the degree of damage to buildings and other man-made structures. Intensity ratings are based on visual observation and are not measured with instruments. The degree of intensity varies from place to place during an earthquake. Specific locations in an area may have an intensity rating of VIII because of soil conditions, structural design, or distance from field epicenter. Intensity scales have generally been replaced by more quantitative measures such as the magnitude scale and ground response based upon seismograph or accelograph records.

An important factor affecting the degree of damage to structures during an earthquake is the frequency characteristics of groundmotion as related to the fundamental periods of vibration of the structure. For sites such as the plain area which are underlain by deep deposits of unconsolidated alluvium, the peak values of the acceleration response spectra tend to occur at high values of the fundamental period, resulting in high (damaging) accelerations being induced in flexible structures such as multi-story buildings. The reverse is true of the area underlain by firm bedrock, i.e., the high accelerations would be induced in rigid structures such as reinforced buildings of only a few stories in height.

In general, the greatest damage to tall structures results where they are built over thick, soft, water-saturated sediments. The least damage occurs where they are built on very firm bedrock. The structural integrity of buildings before the earthquake and whether the natural vibration period of the structure is coincident to that of the ground are both factors that complicate these general concepts.

When the building and the ground approach the same vibration period, the greatest damage is likely to occur. The predominant vibration period of a building can be related in a very general way with its height or number of stories. Taller buildings have a longer predominant vibration period (2 or more seconds). Therefore, they are subject to greater damage where they occur on ground with a longer predominant vibration period (thick, water-saturated sediments). Conversely, 1 or 2 story buildings with short predominant vibration periods on firmer ground may be in trouble. Other factors which contribute to damage potential, such as magnitude, distance, frequency and duration of a particular earthquake, influence the predominant vibration period. For the Ventura County area, unfortunately, none of the factors are predictable with any great degree of confidence.

Intense ground shaking in areas of unconsolidated, water-bearing sediments (alluvium) or wet soils could also result in soil liquifaction, ground rupture, lurching, slumping and lateral movement of nearly level areas and landsliding. The greatest hazard of ground failure in hillside areas is in the form of landsliding and other slope failures. Seismic shaking can renew movement of old landslides as well as result in formation of new slides. Many of the existing landslide features may have been triggered by past earthquake shaking. The combination of relatively weak bedrock, deep weathering, steep slopes and inclined bedding combine to make many areas highly susceptible to landslide failure during seismic shaking.

Illustration 3.4

MODIFIED MERCALLI SCALE OF EARTHQUAKE INTENSITIES

THE MERCALLI INTENSITY SCALE

(As modified by Charles F. Richter in 1956 and rearranged)

*If most of these effects
are observed*

*then the
intensity is:*

*If most of these effects
are observed*

*then the
intensity is:*

Earthquake shaking not felt. But people may observe marginal effects of large distance earthquakes without identifying these effects as earthquake-caused. Among them: trees, structures, liquids, bodies of water sway slowly, or doors swing slowly.....I

Effect on people: Shaking felt by those at rest, especially if they are indoors, and by those on upper floors.....II

Effect on people: Felt by most people indoors. Some can estimate duration of shaking. But many may not recognize shaking of building as caused by an earthquake; the shaking is like that caused by the passing of light trucks.....III

Other effects: Hanging objects swing

Structural effects: Windows or doors rattle. Wooden walls and frames creak.....IV

Effect on people: Felt by everyone indoors. Many estimate duration of shaking. But they still may not recognize it as caused by an earthquake. The shaking is like that caused by the passing of heavy trucks, though sometimes, instead, people may feel the sensation of a jolt, as if a heavy ball had struck the walls.

Other effects: Hanging objects swing. Standing autos rock. Crockery clashes, dishes rattle or glasses clink

Structural effects: Doors close, open or swing. Windows rattle.....V

Effect on people: Felt by everyone indoors and by most people outdoors. Many now estimate not only the duration of shaking but also its direction and have no doubt as to its cause. Sleepers awakened.

Other effects: Hanging objects swing. Shutters or pictures move. Pendulum clocks stop, start or change rate. Standing autos rock. Crockery clashes, dishes rattle or glasses clink. Liquids disturbed, some spilled. Small unstable objects displaced or upset

Structural effects: Weak plaster and Masonry D* crack. Windows break. Doors close, open or swing.....VI

Effect on people: Felt by everyone. Many are frightened and run outdoors. People walk unsteadily.

Other effects: Small church or school bells ring. Pictures thrown off walls, knickknacks and books off shelves. Dishes or glasses broken. Furniture moved or overturned. Trees, bushes shaken visibly, or heard to rustle

Structural effects: Masonry D* damaged; some cracks in Masonry C*. Weak chimneys break at root line. Plaster, loose bricks, stones, tiles, cornices, unbraced parapets and architectural ornaments fall. Concrete irrigation ditches damaged.....VII

Effect on people: Difficult to stand. Shaking noticed by auto drivers

Other effects: Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Furniture broken. Hanging objects quiver

Structural effects: Masonry D* heavily damaged. Masonry C* damaged, partially collapses in some cases; some damage to Masonry B*; none to Masonry A*. Stucco and some masonry walls fall. Chimneys, factory stacks, monuments, towers, elevated tanks twist or fall. Frame houses moved on foundations if not bolted down, loose panel walls thrown out. Decayed piling broken off.....VIII

Effect on people: General fright. People thrown to ground

Other effects: Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes. Steering of autos affected. Branches broken from trees

Structural effects: Masonry D* destroyed, Masonry C* heavily damaged, sometimes with complete collapse. Masonry B* is seriously damaged. General damage to foundations. Frame structures, if not bolted, shifted off foundations. Frames racked. Reservoirs seriously damaged. Underground pipes broken.....IX

Effect on people: General Panic

Other effects: Conspicuous cracks in ground. In areas of soft ground, sand is ejected through holes and piles up into a small crater, and, in muddy areas, water fountains are formed

Structural effects: Most masonry and frame structures destroyed along with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes and embankments. Railroads bent slightly.....X

Effect on people: General panic

Other effects: Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land.

Structural effects: General destruction of buildings. Underground pipelines completely out of service. Railroads bent greatly.....XI

Effect on people: General panic

Other effects: Same as for Intensity X.

Structural effects: Damage nearly total, the ultimate catastrophe.....XII

Other effects: Large rock masses displaced. Lines of sight and level distorted. Objects thrown into air

*Masonry A. Good workmanship and mortar, reinforced, designed to resist lateral forces. Masonry B. Good workmanship and mortar, reinforced. Masonry C. Good workmanship and mortar, unreinforced. Masonry D. Poor workmanship and mortar and weak materials, like adobe

The following are excerpts from a manuscript in preparation by D.R. Nichols, U.S. Geological Survey.

Ground Shaking - Probably the most difficult task today, in terms of the predictive capability of the geologist and seismologist, is devising a reasonably reliable method of predicting "ground shaking" effects --what most people and structures react to during an earthquake. Examination of damage from numerous past earthquakes, in lieu of conclusive strong-motion seismograph records, has suggested to geologists and engineers that the greatest damage to tall structures results where they are built over thick, relatively soft, water-saturated sediments and that the least damage occurs where they are built on very firm bedrock. Although engineers have shown that while great thicknesses of wet unconsolidated sediments may amplify the ground motion, perhaps a more critical measure of damage is a determination of the "predominant period" of the building and of the ground on which it rests. The predominant period of a building can be related in a very general way to its height or number of stories. Taller buildings have a longer predominant period (2 seconds or more). Therefore, they are subject to greater damage where they occur on ground with a longer predominant period (thick, saturated sediments). Conversely, one or two-story buildings with a short predominant period may be in trouble on firmer ground. Further complicating this very generalized picture are a wide variety of other factors that may contribute significantly to a damage potential: magnitude of a particular earthquake, distance and direction from the epicenter and causative fault, duration of shaking and the structural integrity of buildings before the earthquake, and many others. The greatest damage is likely to occur where the predominant ground period is coincident with that of the greatest number of high-rise buildings. However, a prediction of ground shaking at a particular spot or point is subject to a great variety of conditions, only some of which are predictable with confidence. For example, a magnitude 5 earthquake on the San Andreas Fault at Hollister may have the same damage pattern at a particular locality as a more distant 7.5 magnitude earthquake on the Hayward or Calaveras fault.

Ground Failure - Earth materials in a natural condition tend to reach equilibrium over a long period of time. In geologically active areas such as California and Alaska there are many regions where earth materials have not yet reached a natural state of stability. For example, most of the valleys and bay margins are underlain by recent loose materials that have not been compacted and hardened by long-term natural processes. Landslides are common on most of the hills and mountains as loose material moves

downslope. In addition, many activities of man tend to make the earth materials less stable and hence to increase the chance of ground failure. Some of the natural causes of instability are earthquakes, weak materials, stream and coastal erosion, and heavy rainfall. Human activities that contribute to instability include oversteepening of slopes by undercutting them or overloading them with artificial fill, extensive irrigation, poor drainage or even groundwater withdrawal, and removal of stabilizing vegetation. These causes of failure, which normally produce landslides and differential settlement, are augmented during earthquakes by strong ground motions that result in rapid changes in the state of earth materials. It is these changes, by means of liquifaction and loss of strength in fine-grained materials, that result in so many landslides during earthquakes as well as differential settlement, subsidence, ground cracking, ground lurching, and a variety of transient and permanent changes in the ground surface.

Mechanisms of Failure - Liquifaction is a common mechanism causing many types of ground failure. It occurs when strength of saturated, loose, granular materials (silt, sand, or gravel) is drastically reduced, such as may occur during an earthquake. The earthquake-induced deformation transforms a stable granular material into a fluidlike state in which the solid particles are virtually in suspension similar to quicksand. The result, where the liquified materials are in a broad buried layer, may be likened to the action of ball bearings in reducing friction in the movement of one material past another. The Juvenile Hall Landslide during the 1971 San Fernando earthquake resulted from liquifaction of a shallow sand layer and involved an area almost a mile long and a failure surface that had a slope of only 2-1/2 percent (Youd, 1971, p. 107, 108). Where the liquified granular layer is thick and occurs at the surface, structures may gradually sink downward. The tilting and sinking of buildings during the Niigata earthquake illustrate this phenomenon.

Results of Ground Failure - Although the basic causes of ground instability are simple in concept, the consequences are often complex and highly variable. They include numerous varieties of landslides, ground cracking, lurching, subsidence, and differential settlement. Moreover, these types of ground failure occur on a wide variety of ground conditions. Landslides, for example, do not require a steep slope on which to form, particularly during earthquakes. Many occur on slopes that are virtually flat, and the surface on which they fail may be very shallow (1 to 2 feet deep) or as much as hundreds of feet below the ground surface. The type of ground failure that develops in a given area is determined by the nature of the natural or man-made disturbance that occurs and partly by the topographic, geologic, hydrologic, and geotechnical characteristics of the ground.

Ground cracking usually occurs in stiff surface materials and is associated with changes in surface topography or materials. For example, during the 1964 Alaskan earthquake, much of the ground cracking that occurred along river flood plains adjacent and parallel to stream channels and along road and railroad embankments resulted from differential movement owing either to liquifaction or to lateral spreading of a relatively soft, deeper layer under a stiffer surface layer. Cracks may be only hairline or several feet wide and from a few feet to hundreds of feet long.

Ground lurching may be both a transitory and permanent phenomenon. During earthquakes, soft saturated ground may be thrown into undulating waves that may or may not remain when the ground motion ceases. The same or similar ground surface appearance may also result from permanent differential settlement of the ground, which can be caused by loss of soil strength or by liquifaction. Commonly, the water freed by liquifaction of buried and confined granular layers is forced to the ground surface, moving laterally toward steep slopes or vertically along the planes of weakness in the overlying layers. As the water moves toward the surface or "free face," it often carries with it some of the sand. Thus, "sand boils," "sand volcanoes," "sand ridges," and similar anomalous features attest to the occurrence of liquifaction. As sand and water are removed from the subsurface, the ground settles, often differentially because the sand and water are seldom removed evenly over broad areas. The resulting effects on buildings can be catastrophic.

Subsidence of as much as several feet may occur over a broad area underlain by a thick sequence of sedimentary deposits. For example, after the 1906 earthquake, a well casing was reported to have "risen" two feet out of the ground, when, in fact, the ground around it probably liquified or compacted as a result of the shaking. Subsidence is likely to be greatest in areas where there has been withdrawal of fluids (ground water or oil) over a long period of time. Lesser amounts of subsidence can occur even where fluid withdrawal has not taken place, as in the Homer area of Alaska in 1964. Compaction effects may be predicted with some degree of assurance over fairly broad areas (up to 1 or 2 miles) and even on a site basis, especially when the cause may be liquifaciton.

Tectonic Deformation - Earthquakes may produce major differential vertical and horizontal movements over broad parts of the earth's crust. For example, as a result of the 1964 Alaskan earthquake, between 70,000 and 110,000 square miles of both the sea floor and land in southern Alaska were warped, elevating or depressing them as much as 6 feet; elevation changes locally exceeded 50 feet

(Hansen and others, 1966, p. 17). While the effect of compaction and tectonic subsidence may appear the same locally, the mechanisms differ greatly and the total area affected will be much greater where tectonic deformation occurs. Tectonic land changes result from major movements in the earth's crust, and neither their location nor their magnitude is predictable. Therefore, little can be done to minimize the effects of these changes before they occur.

All of Ventura County lies within the highly active earthquake region of Southern California. Preliminary estimates by R. Greensfelder (California State Division of Mines and Geology, unpublished preliminary research information) indicate that most of Ventura County can be subject to as strong earthquake shaking as can be expected anywhere in California. Only the area of the Santa Monica Mountain is estimated to have slightly less severe ground shaking potential.

GENERAL EFFECTS OF THE HAZARD

PRIMARY EFFECTS

The primary effect of ground shaking is the damage or destruction of structures and infrastructures and thus the potential for the loss of life or sustaining injuries. The severity of the effect is dependent on many factors such as the strength and design of the structure to withstand shaking; composition and depth and the geologic structure of underlying earth materials; the presence of free groundwater and the topography. In general, all structures in areas subject to ground shaking will be affected.

Damage to structures during ground shaking can range from minor cracking of plaster to total collapse and or overturning. No structure can be assured to be designed and constructed to withstand damage from a strong earthquake. Some damage, whether it be to the structure or its contents, can be anticipated.

Ground shaking could cause severe damage to most utilities including pipelines, power lines, generating and convertor facilities, roads and bridges, if such structures were not constructed to withstand the shaking. Ground surfaces could rupture, crack and subside up to several feet in areas of unconsolidated alluvium resulting in damage to structures located in these areas.

SECONDARY EFFECTS

As a result of severe shaking and structural failures there are other secondary effects possible. Such effects include:

1. Cost of rehabilitation
2. Disruption of utilities and services for a substantial length of time
3. Seiches
4. Liquefaction
5. Possible sympathetic movement of other faults
6. Temporary and long term psychological effects
7. Adverse affect on the quality of water in ground water aquifers.

GENERAL INVENTORY OF THE HAZARD

LOCATION OF THE HAZARD

The hazard exists throughout Ventura County and may significantly increase, wherever there is ground material that could significantly amplify the ground waves of an earthquake and produce high intensity ground shaking. Every place in the surrounding area would be shaken by an earthquake, the area affected would generally be determined by the magnitude of the earthquake. Those areas that might be shaken more than others are in the hazard zones. (Shown on Hazard Plate II).

The highest amplification of ground shaking occurs in areas where the long period wave shaking is greatest, designated as Area A on Hazard Plate II. Basically, this is the Oxnard Plain and the Santa Clara River in the south half of the County and in Lockwood, Cuyama, and Cuddy Valleys in the north half. Areas that could experience some amplification of long period shaking generally surround these areas and extend up the canyons of the major rivers and creeks.

The areas with the greatest amplification of short period shaking are along the base of the hills and in minor river valleys and in the broken bedrock along fault lines such as the San Cayetano and Simi-Santa Rosa Faults. Slight to moderate amplification of short period oscillations may occur on terrace deposits or soft bedrock, which has a thin soil covering. These materials are found in young hill areas such as South Mountain, Oak Ridge, Sulphur Mountain, and the north coastal hill lands and the Piru area in the south half of the County. In the north half these are along the margins of the valley areas such as Hungry and Lockwood Valleys and hill lands north of Cuyama.

HISTORY OF THE HAZARD

Southern Ventura County

The southern County area is considered that portion southerly of the east-west projection of Nordoff Ridge located immediately north of the Ojai Valley. Even though the historic record indicates that no strong earthquakes or surface displacement have occurred along the faults within the southern county area, the likelihood of the occurrence of one or more of such events within 50 to 100 years is not remote. The recent San Fernando earthquake occurred along a fault having little historic record of activity. Several of the faults within the south half of Ventura County, such as the Santa Susanna and San Cayetano, are similar in structure and subject to similar tectonic forces. Crustal deformation resulting in similar earthquakes will likely continue into the indefinite future.

The history of strong earthquakes provides an indication of what will probably occur in the future, however, the record does not provide a statistically sound basis for prediction. It is probable that earthquakes of magnitude 6 and larger will occur in the future within the south half of the county area or in the nearby offshore areas, and it would be consistent with past experience if several such shocks occurred in the next century. Surface displacement associated with the earthquakes is also possible.

The following is a portion of the summary of faulting and seismicity of the southern County area taken from the "Geology and Mineral Resources Study of Southern Ventura County" (1972) prepared by the State Division of Mines and Geology in cooperation with the Ventura County Department of Public Works:

"The earthquake history of Ventura County, particularly of the more populous southern part, is dominated by small to moderate shocks. Many of these shocks have been severe in their local, epicentral areas, but regionally have caused only light damage. No earthquake greater than magnitude 4.7 has been recorded in Ventura County, or the immediate offshore area, since 1934 when adequate instrumental records became available. These relatively minor shocks have caused local damage but no recorded loss of life. A review of the earlier less accurate record from 1769 to 1934 suggests a similar history for the southern County region. More serious than effects from local shocks have been the effects from relatively numerous moderate to large earthquakes whose epicenters are located outside of southern Ventura County. These shocks have caused considerable damage but no recorded loss of life.

Several larger, historic earthquakes are especially important to the evaluation of future seismic risk in

southern Ventura County. On December 21, 1812, an earthquake, probably located offshore south of Santa Barbara, damaged missions from Purisima Concepcion, near Lompoc, to San Fernando on the south. The tower of the San Buenaventura Mission was wrecked and much of the facade had to be rebuilt. This earthquake was accompanied by seismic sea waves which had reported runup heights of 30 to 50 feet between Santa Barbara and Gaviota and 15 feet or more at Ventura (Wood and Heck, 1966). Such waves today would do considerable damage to many parts of the now heavily settled coastal areas of Ventura County.

On January 9, 1857, the great Fort Tejon earthquake, with its epicenter probably on the San Andreas fault, close to the northeast corner of Ventura County, caused significant damage in the southern part of the County. The roof of the Mission Church at San Buenaventura fell in (Townley and Allen, 1939). Six miles from the south of the Santa Clara River the bed of the river was severely cracked. Wood (1955, p. 53) quoted a report describing the cracks as "being six or eight inches across, and extending in a direction SE and NW." Quoting further he said that "on either side of the cracks lay a ridge of wet sand." These cracks were probably due to lurching and liquifaction in the saturated alluvium of this area.

Wood continued, noting:

These appearances were visible as far as I could see up and down the bed of the river. Near the mouth of the river the cracks were longer and wider. Persons residing within a mile of the entrance say that the water was thrown out from the cracks as high as six feet, and that large blocks of earth sank several feet below the former level, and there remain.

A second important earthquake is the June 6, 1925 shock of magnitude 6.3, which destroyed the business section of Santa Barbara and caused some damage in Ventura. An offshore shock on June 30, 1941, magnitude 5.9, cracked some walls and plaster, broke windows and dishes and damaged considerable shelf-stock in some stores in Ventura.

The intensity of shaking reported in much of Ventura County from the February 9, 1971, San Fernando earthquake was sufficient to cause minor damage and to cause breakage of some goods thrown from store shelves. In Santa Susana, some older buildings were severely damaged, with at least one or two razed. At least a few rockfalls and one small bedrock landslide occurred north of Simi Valley in the Tapo Canyon area, just south of the Santa Susana fault. Small displacement occurred on this fault during the

earthquake in the northwestern Sylmar area. The fault extends west, where it joins the Oak Ridge fault and possibly the San Cayetano fault system in the Piru-Oak Ridge area.

The questions, "which faults of southern Ventura County are active or potentially active?" has not been answered fully. The Red Mountain and San Cayetano thrust fault zones, which together nearly span the County (See Hazard Plate I), should be considered active. Holocene and Pleistocene sediments are displaced by the Red Mountain thrust, and similar physiographic features on both the Red Mountain and San Cayetano thrusts, also suggest Holocene displacement. In addition, aerial photos show many ground surface lineaments and other phenomena which may reflect Holocene or later Quaternary faulting, and should be investigated. One alignment near the base of the Ventura Foothills, roughly corresponds to a fault shown in cross section by Ogle (1969), who correlates it with the offshore, Pitas Point fault.

Several reverse faults, which apparently act as barriers to ground water in the alluvial areas, were also probably active during the late Quaternary, as described by California Water Resources Board (1953). These include the Springville fault at the western Simi Valley area, the western Oak Ridge (Saticoy) fault in the Oxnard Plain area, and the Santa Ana fault in the Oak View area (a fault zone which has raised the Upper Ojai Valley relative to Ojai Valley). The Camarillo fault may not act as a ground water barrier, but California Water Resources Board (1953, p. B34) stated that the fault may have offset alluvium.

A problem in southern Ventura County equally as serious as the identification of active or potentially active faults is the problem of identifying the geologic units as to their seismic response characteristics. For example, Richter (1959, p. 143) stated that much of the alluviated area of the Santa Clara Valley and the Ventura basin should expect shaking sufficient to cause considerable damage in specifically designed buildings and great damage to normally substantial buildings. In the eastern part of the Ventura basin this was demonstrated during the San Fernando earthquake. The expected damage to areas where ground water is within 15 feet of the surface could be even greater, but would be relatively less in areas underlain by older alluvium and even less on more indurated or cemented Tertiary rocks. Older landslides may be re-activated or new landslides may originate in some areas of Tertiary rocks of the County during an earthquake. Especially landslide prone is the Pico Formation, and to a lesser extent the Modelo/Monterey and Rincon Formations."

Northern Ventura County

The most important faults in the vicinity of the northern County area are the San Andreas, Big Pine, Garlock, San Gabriel and Frazier Mountain thrust, all of which converge at the northeast corner of Ventura County, and the Santa Ynez in the southern part of the north half of the County. All of these faults except perhaps the Frazier Mountain thrust are considered to be active, i.e., are potential focal points for the occurrence of earthquakes and displacement of the ground surface. Other mapped and unknown faults within the north half may also prove to be active by future displacement or detailed investigations.

Historic Record - Reliable accounts of California earthquakes date from about 1800. Since that year it is estimated that 35 to 40 earthquakes of magnitude 6.0 (Richter Scale) or larger have occurred in southern California. Over 20 of these occurred since 1912. Three of the earthquakes could have caused substantial damage to major structures in the north half had such structures been located there. These three earthquakes were the Northern Ventura County of 1852, Fort Tejon of 1857 and the Kern County of 1952.

The Big Pine fault, a major left-lateral fault with some oblique slip (subject to both horizontal and vertical displacement), may have had measurable movement during historic time. The earthquakes (apparently several) of November 1852 were accompanied by about 30 miles of surface faulting in Lockwood Valley. The exact location of the surface breaks is unknown, but geologic evidence and reports by others indicate that it may have been along the Big Pine Fault. Evidence of young movement along the fault includes scarplets that cut terrace deposits and apparent left-lateral offset of stream channels.

Several other faults found in the Lockwood Valley area have had recent movement by virtue of their cutting of terrace deposits and offset of other faults. These faults range from several hundred to a few thousand feet in length. Some of them indicate the region has recently undergone, and is probably still undergoing, compression along north-south directions.

Future Earthquake Potential - The historic record shows that the north half has experienced several severe shocks originating along faults both within and immediately outside of the area. The geologic record shows that a high level of tectonic activity has continue to the present time.

The history of severe earthquakes provides an indication of what will probably reoccur in the future,

however, the record does not provide a statistically sound basis for prediction. It has been found, however, that the number of large earthquakes that occur in a region is related to the number of small earthquakes.

Movement of the land mass west of the San Andreas fault relative to the east side, has been fairly well substantiated by the geologic record as well as precise surveying, and is about 2 inches per year. That portion of the San Andreas fault immediately north of the County has not shown displacement since 1857 nor has any been reported along the Big Pine or other faults in the north half since 1852.

Geologic and survey evidence indicates that stress is building up along the San Andreas fault to the north. It is just a question of time until the fault in this area again displaces with a high probability that the resulting earthquake will be severe. Prediction of when displacement will occur is not possible at this time, however, it is likely that it will occur within 100 years and possibly much sooner.

Earthquakes and surface displacement originating along faults within the north half is also highly possible, but again, prediction of when is not possible. Determination of the potentially most active faults would require extensive field investigation and was not completed during this study. However, previous studies and published information indicates that many recently active faults may exist within the region. In addition, the apparently active compressional forces which continue to affect the area, as recently reflected by the San Fernando earthquake, provide the means through which future earthquakes could occur along the known as well as other presently unknown, faults within the area.

Since 1852 the northerly portion of the north half has experienced severe shaking probably on the order of XI on the Mercalli Modified Intensity Scale during three earthquakes. One of these may have been centered on the Big Pine Fault during which rupturing of the ground surface occurred. Earthquakes of equal or greater intensity can be expected to affect the area in the future, and it would be consistent with past behavior if at least two such events occurred in the next century. It is likely that at least one of these events will be centered along the nearby San Andreas fault.

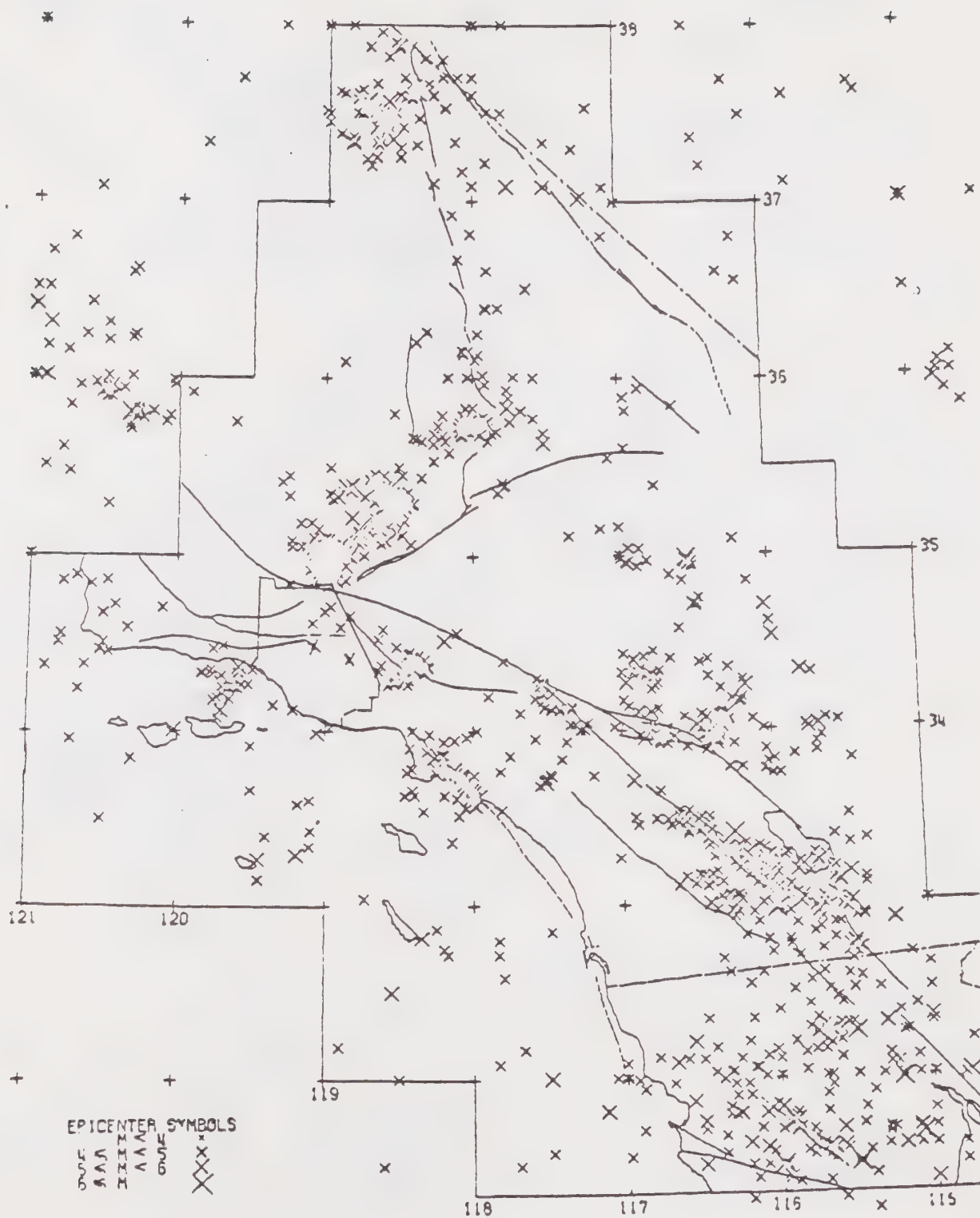
A large earthquake (7.0 magnitude or greater) in the vicinity of the north half would cause intense shaking with possible ground deformation and rupturing in valley alluvium, man-made fills and marginally stable hillsides. The resulting damage to structures would be great especially

during the wet season when groundwater is at its highest level of in areas where groundwater is being recharged by lakes or surface irrigation.

It is impossible, based upon the meager available information and experience with earthquake activity in California, to accurately predict the degree of shaking which could result from a great earthquake such as those of the not so distant past which affected the region. However, it is not unreasonable to expect bedrock accelerations of over 1.0g (or equivalent to the acceleration of gravity) and over 45 seconds of maximum shaking duration. The degree of shaking would, of course, be much greater resulting in higher accelerations, in areas underlain by alluvium or valley sediments. Peak bedrock accelerations in the range of 0.5g to 1.0g were recorded during the relatively small San Fernando Earthquake of 1971.

Illustrations 3.5 - 3.7 indicate the approximate number, epicenter and magnitude of earthquakes recorded in the vicinity of Ventura County since 1932.

Illustration 3.5
REGIONAL EPICENTER MAP 1932-1971



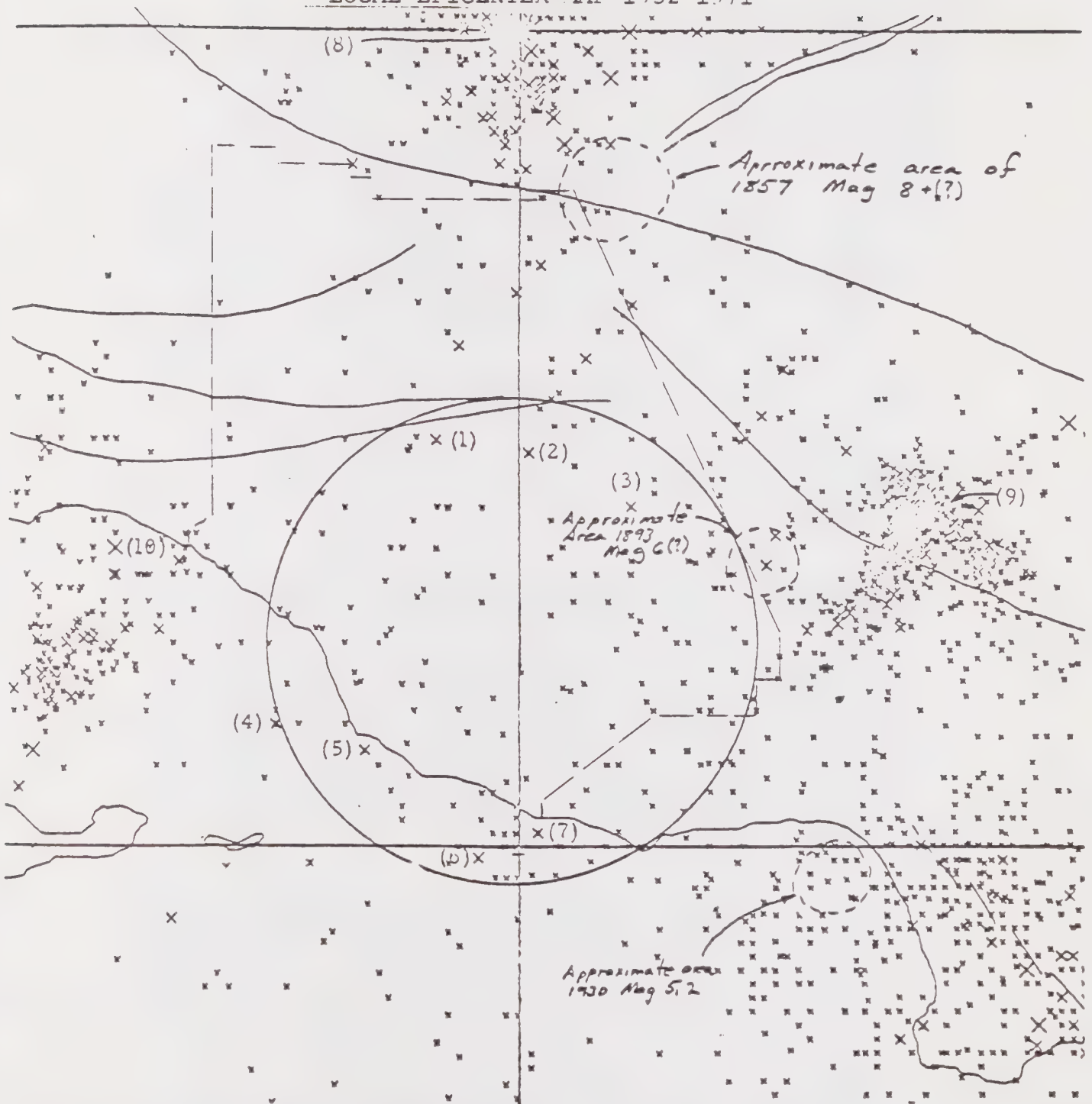
Note: Earthquakes less than magnitude 4.0 not plotted

Ref: Unpublished thesis material by James A. Hileman,
California Institute of Technology, 1972.

Map of the North Pacific Ocean showing earthquake epicenters from 1952 to 1977. The map covers the area from 120°W to 118°W and 34°N to 35°N. It includes a grid of latitude and longitude lines, a coastline of the western United States, and a dense distribution of earthquake epicenters marked with 'x' and dots. A specific event is labeled 'Feb. 21, 1973' near 119.5°W, 34.5°N.

3000
 2000
 1000
 0

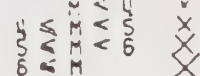
Illustration 3.7
LOCAL EPICENTER MAP 1932-1971



<u>Epicenter</u>	<u>Date</u>	<u>Magnitude</u>
(1)	11/17/54	4.4
(2)	9/ 3/42	4.5
(3)	6/ 1/46	4.1
(4)	8/22/50	4.2
(5)	3/18/57	4.7
(6)	5/29/55	4.1
(7)	4/16/48	4.7
(8)	7/21/52	7.7
(9)	2/ 9/71	6.4
(10)	7/ 1/41	5.9

0 20
MILES

EPICENTER SYMBOLS



DEFINITION OF THE HAZARD ZONE

The ground shaking hazard zones as indicated on Hazard Plate II (Southern Ventura County and Northern Ventura County) are based on the concept that ground shaking is partly determined by the thickness of the alluvium or unconsolidated material overlying relatively firm bedrock or consolidated earth material and the depth to the ground water table. The zones identified are as follows:

Zone A. Areas underlain by alluvium more than about 50 to 100 feet in thickness and with groundwater levels at about 15 feet or less below ground surfaces. These areas could experience the greatest amplification of long period ground vibration. Therefore, buildings such as high rise structures which have long natural vibration periods could be more susceptible to damage in this zone.

Zone B. (So. County only) Areas underlain by alluvium more than about 50 to 100 feet in thickness and with groundwater levels more than 15 feet below the ground surface. These areas could experience moderate amplification of long period ground vibration. Therefore, high rise structures which have long natural vibration periods could be more susceptible to damage in this zone but less susceptible than in Zone A.

Zone B-C. (No. County only) Areas underlain by alluvium less than about 50 feet in thickness and with groundwater levels more than about 15 feet below ground surfaces. These areas could experience the greatest amplification of short period ground vibration. Therefore, low rise buildings which have short natural vibration periods could be more susceptible to damage in this zone.

Zone C. (So. County only) Areas underlain by broken bedrock adjacent to faults or where ground alluvium less than about 50 feet in thickness. These areas could experience the greatest amplification of short period ground vibration. Therefore, low rise buildings which have short natural vibration periods could be more susceptible to damage in this zone.

Zone D. Areas underlain by soft sedimentary bedrock or Terrace Deposits with some soil cover (generally thicker on lower slopes). These areas may not experience as severe shaking as the other zones, but more than Zone E because of softer materials and relatively thin soil cover. Amplification of short period ground vibration could be slight to moderate. Therefore low rise structures of short natural vibration periods could be somewhat more susceptible to damage.

Zone E. Areas underlain by hard bedrock with little or no soil cover. These areas may not experience as severe shaking as the other zones because the thin or lack of unconsolidated cover (soil) or significant free groundwater will not allow amplification of shaking.

Man-made structures within a zone will respond differently depending upon their natural periods of vibration. Similarly, two structures with the same natural period will respond differently in different zones. Generally those structures which have a natural frequency close to the ground frequencies that receive the greatest amplification within the zone would sustain the greatest shaking.

The boundaries of the Ground Shaking Hazard Zones should be considered as only approximate. In addition, the estimated response of structures and amplification of certain ranges of ground vibration may vary greatly within a given zone during a given earthquake depending upon its origin, i.e., magnitude, location, distance and depth.

The ground responses estimated for each zone represent generalizations illustrative of the possible variation in the predominant ground response possible from one area to another resulting from perhaps a large earthquake generated along the nearest portion of the San Andreas Fault. The highly complex nature of the geology of Ventura County and the great number of faults along which earthquakes could occur does not allow accurate determination of the range of predominant ground responses which could occur within any one zone.

Present technology or "state-of-the-art" will, however, allow determination of the likely ground response within an individual site proposed for development during an anticipated earthquake, but only after detailed geologic, seismologic and soils engineering investigation of the site.

NATURE OF INFORMATION

The information used in delineating the Ground Shaking Hazard Zones on Hazard Plate I is regional in nature and is based upon available groundwater levels and the presence of alluvium as mapped (compiled) as part of the recently completed report entitled "Geology and Mineral Resources Study of Southern Ventura County" (1973) and the Los Angeles Sheet of the Geologic Map of California, both prepared by the State Division of Mines and Geology

and estimated depths of alluvium. The hazard zone locations, boundaries and estimated ground response are not sufficiently accurate on which to base design criteria for individual site development or even provide a basis for land use planning except in the broadest sense without more detailed investigation.

The technical information is based primarily upon statistical data and seismic reports which date back to only the late 1800's and recent experience and research by various governmental agencies and universities. Much of the information utilized was from that developed and published since the San Fernando Earthquake of February, 1971.

The Ground Shaking Hazard Zones designated on Hazard Plate I are only approximations and of insufficient accuracy to base any building code requirements. In addition, the estimated ground shaking characteristics are general approximations and may vary greatly within a given zone during a given earthquake.

Recent communication with the State Division of Mines and Geology indicates that the Division believes that the "state-of-the-art" for predicting ground response to waves transmitted by earthquakes has not reached the point where regional maps delineating zones showing predictable intensity or type of shaking can be made with any degree of accuracy.

GENERAL MANAGEMENT RESPONSIBILITY

INVESTIGATION

Research and experience dealing with the nature and mechanism of earthquake ground shaking is being conducted by various Federal and State agencies as well as by universities and professional organizations. Much of this work is being conducted on a state-wide basis, however, indirect benefit to Ventura County will be gained through developed technology.

The State Division of Mines and Geology is currently investigating the extent of the hazard to Ventura County as part of the cooperative Geologic Hazards Investigation scheduled for completion by July of 1975.

Additional investigation is being conducted on a continuing basis by:

Private Geologic Consultants who provide original information during investigations for private developments.

Ventura County Department of Public Works which:

- a) Provides review and evaluation of Geologic and Soils and Foundation Engineering reports prepared for private projects within the unincorporated area and for the Cities of Camarillo, Simi Valley and Santa Paula.
- b) Performs Geologic and Soils Engineering investigations for County projects such as roads and flood control facilities.
- c) Coordinates, evaluates, and compiles geologic information derived from public and private investigations within the unincorporated areas and for the Cities of Camarillo, Simi Valley and Santa Paula.

Individual site investigation to provide detailed estimates of ground shaking sufficient for design purposes would include determination and analysis of the following information:

- 1. Depth and character of earth materials.
- 2. Presence and depth to groundwater.
- 3. Depth to and character of bedrock.
- 4. Evaluation of past earthquake records.
- 5. Estimate of the most likely earthquake to occur within the life of the proposed structure based upon existing earthquake records and evaluation of the potential activity of nearby as well as distant faults.
- 6. Evaluation of applicability of ground response records from other earthquakes and modification of them as necessary to suit the site in question or determination of ground response by computer methods.

WARNING

There is no way to prevent or predict to any degree of accuracy earthquakes or severity or kind of ground shaking during earthquakes at the present. Although it may be that developing technology will enable earthquakes to be predicted, in the not too distant future, the potential availability of such information may have undersirable side effects, such as drastic and sudden

effects on land values, insurance rates, business and the disruptive impacts caused by the possible large, rapid migrations of the populace out of affected areas.

ALLEVIATION

Regulation of public and private land development within both incorporated and unincorporated areas is administered by:

City and County Departments of Planning,
Public Works, and Building and Safety

City Councils and the Board of Supervisors

Enforcement of the Uniform Building Code and City and County regulations and policies can be effected by the above agencies through requirement of review of proposed land use and evaluation of investigation and engineering studies for private development and public projects. Such reviews and evaluations can be performed by qualified engineering geologic and soils engineering staff or by retention of consultants.

Since alleviation of the hazard is largely accomplished through land use controls, the agencies, departments and legislative bodies making land use decisions have the primary responsibility for alleviating the hazard. City and County Planning Departments can utilize available hazard information to determine the need for any additional, more detailed studies and for formulating investigation and design requirements to avoid improper land use and inadequate construction. Decisions concerning adoption of these recommendations rests ultimately with the Planning Commissions, City Councils and the Board of Supervisors. Other bodies making land use decisions include port districts and redevelopment agencies.

Alleviation of existing hazards can be effected by replacement or strengthening of structures which may not be designed to resist strong ground shaking or modification of land uses as hazardous structures are removed. Determination of whether structures are hazardous would require detailed geologic-seismic and soils engineering investigation of seismic and foundation conditions and structural engineering evaluation of the particular structure.

LOCAL DISCUSSION

LOCAL INVENTORY OF THE HAZARD

The "A" hazard zones are those that have a high water table level and deep alluvium. They may be subject to the greatest amplification of long period vibrations. The areas affected include: Pleasant Valley and the lowest part of the Santa Clara River Valley in the south half of the County. Also included in the "A" hazard zone are the sides of Lockwood Valley and Cuddy Valley and the entire Cuyama Valley floor in the north half of the County.

Other areas with deep alluvium but possibly without the higher potential for amplification are designated as area "B" on Hazard Plate II. These areas include basically the margins of the "A" zone in the Santa Clara Valley, the flood plains of Calleguas Creek and Arroyo Santa Rosa, the southern edge of the Las Posas Valley, Simi Valley and the main Ojai Valley.

The area with possibly the greatest amplification of short period ground waves are designated "C" on the south half map. These are most of the valley margins surrounding the long period amplification or in otherwise unaffected valleys, such as, the Thousand Oaks area. The zone also follows some fault lines in the broken bedrock (fault gauge), such as, the San Cayetano fault between Fillmore and Ojai and between the Simi and Santa Rosa Valleys. It includes most of the valley bottoms in the north half, which are not as seriously affected.

The areas designated as slight to moderate short period amplification are composed mainly of younger sedimentary bedrock and terrace deposits, designed at area "D" on the Hazard Plate II. They include the relatively new hill area south of the San Cayetano and Oak Ridge faults in the south half and the high margins of the valley areas in the north half.

LOCAL RESOURCES AFFECTED BY THE HAZARD

Comparison of Hazard Plate II with a map of present land uses within the County would indicate that schools, commercial and industrial areas, residential areas, rest homes and other public buildings and vital facilities are

affected by zones of varying severity of potential ground shaking. In general the urbanized areas are located within the zones of greatest amplification of long period vibrations.

On the basis of present information, however, it cannot be concluded that any of the structures or facilities are unsafe. It is possible, however, that the investigation of many critical or vital structures would show that the degree of structural resistance to shaking may be less than desireable.

FINDINGS (Including incorporated areas)

PROBABILITY OF OCCURENCE

Available geologic information indicates that the potential of strong ground shaking occurring over much of the County as a result of an earthquake along one of the major faults within the County, within the useful life of existing structures, is high when compared to other areas of the State.

Ventura County is considered subject to a higher than State-wide hazard level from ground shaking because of the nearby presence of several large, potentially active fault systems. Exactly where, when, and how strong the next earthquake will be cannot be determined.

SEVERITY OF THE HAZARD

The State Division of Mines and Geology in their publication entitled "Urban Geology" (1973, Bulletin 149) indicates that on a State-wide basis the potential hazard to structures from ground shaking is higher than any other hazard. The anticipated losses from ground shaking for the years 1970-2000 are estimated to be over twice that from landsliding and over 200 times that estimated for fault displacement.

In the event of a strong earthquake (6.0 - 7.5 magnitude) originating in the vicinity of the southern County area or a major earthquake (8.0+ magnitude) along the San Andreas Fault, damage to many existing structures could be severe and some loss of life could occur.

The present level of knowledge and state-of-the-art concerning ground shaking does not allow a complete determination of the factors affecting the type or severity of ground shaking that will or could affect areas within the County. Indeterminate factors include location of the earthquake, direction of waves generated, type of predominant waves, magnitude, type of fault movement, density and depth of earth materials, etc.

The effects of the hazard can be reduced by prudent location and design of proposed important structures and vital facilities and determination of which such existing structures and facilities should be strengthened, replaced or modified in use.

RESOURCES AFFECTED

In general zones A and B encompass the urbanized areas and flood plain areas in the County. Zone C includes the foothill areas with some urbanization, Thousand Oaks and valley bottoms in the north half not included in more severely affected zones and the area along some fault zones.

NATURE OF INFORMATION

The conclusions provided by this study are based primarily upon historic experience as well as the considerable scientific research which has been reported, much of the information has been required since occurrence of the 1971 San Fernando Earthquake.

The hazard boundaries as well as ground responses indicated by Hazard Plate II are at best conjectural. The information is only illustrative of the wide range of ground shaking that can be anticipated over relatively short distances based upon the type and depth of earth materials and presence of groundwater. Other factors which must be evaluated in determination of potential ground response include density of earth material, location, magnitude, and depth of the earthquake, type of bedrock, and type of faulting causing the earthquake. Determination of these factors, and only within certain limits, requires detailed investigation of an individual site.

The current cooperative GEOLOGIC HAZARDS INVESTIGATION being conducted by the State Division of Mines and Geology for the Ventura County area will provide additional necessary information for future updating of this portion of the Seismic Safety Element. The zone boundaries shown on Hazards Plate II must be considered approximate and subject to change as more detailed information becomes available.

OPTIONS

The following are a variety of alternative responses or "options" to the hazard. The appropriateness of each option will depend upon the specific conditions spelled out in the FINDINGS section, and the feasibility of implementation of each option.

1. Encourage performance of regional studies by qualified Federal and State agencies such as the U.S. Geological Survey and the State Division of Mines and Geology or private research firms in order to more accurately determine areas of potential hazardous ground shaking.
2. Encourage and participate in cooperative studies with the above agencies.
3. If necessary, retain private consultants for more detailed study and determination of areas of potential hazardous ground shaking.
4. Adopt the Uniform Building Code and the additional provisions of the County Subdivision Ordinance, Building Regulations and the Land Development Manual or equivalent requirements for all land development.
5. Provide adequate enforcement of the aforementioned requirements by requiring that each proposal for land development and reports and plans submitted be reviewed by qualified personnel registered and certified by the State such as professional engineers, soils engineers and engineering geologists.
6. Establish the hiring of adequate enforcement through qualified staff or retaining private consultants or County services on an as-needed basis.
7. Adopt current investigation guidelines for proposed land development to determine if any design safeguards above current Uniform Building Code standards are necessary.
8. Require geologic-seismic and soils engineering investigation of ground shaking potential for all proposed structures whose failure could result in danger to life and property or great monetary loss.
9. Require structural evaluation of all existing important structures to insure conformance to current Uniform Building Code requirements in regard to resistance to ground shaking.

10. Require the design of buildings, utility systems and other facilities, which need to remain operable after an earthquake, be built to resist strong ground shaking forces.
11. Design and install auxiliary equipment, facilities and machinery which must remain operable after an earthquake to resist ground shaking effects.
12. Design buildings for varying requirements for ground shaking resistance based on type of use and number of occupants, in a manner similar to that now generally required for fire resistance.
13. Explore incentive methods of inducing owners of existing buildings or facilities to take voluntary measures to investigate the resistance of structures to ground shaking and implement corrective measures where such structures are found to be deficient structurally.
14. Determine acceptable risk to life and property through forecasts and scenarios of ground shaking effect of various earthquake intensities.
15. Develop and implement an evaluation system to determine acceptable risk of ground shaking in terms of economic and social costs, environmental impact, risk to life and property, and government responsibility.
16. Evaluate disaster plan demands and potential effectiveness in terms of various earthquake intensities. Create County-wide systematic review by Emergency Preparedness Organizations and Police Departments on contingency disaster plans and programs.
17. Refine information and criteria at the micro-scale to mitigate ground shaking effects: land use compatibility, building location, evacuation routes, circulation, utility location, fire prevention, and emergency communications systems.
18. Evaluate existing public utility systems in terms of susceptibility and acceptable risk of ground shaking.
19. Evaluate water management plans and programs as to effect on water tables and propensity for ground shaking.

FLOODING

locations. In cases where structures have been constructed, regional studies can, in many places, delineate potential problem areas before damaging movement occurs. These studies can be conducted by local agencies and/or by cooperation between the property owners affected.

Presently, little is known of the potential for low-angle landsliding resulting from liquefaction of sediments during earthquake shaking or of areas in which this hazard exists. As previously indicated, this hazard is being evaluated under the Cooperative Geologic Hazards Investigation being conducted by the State Division of Mines and Geology.

ALLEVIATION

Regulation of public and private land development within both incorporated and unincorporated areas is administered by:

City and County Departments of
Planning, Public Works, and Building
and Safety

City Councils and the Board of
Supervisors

Enforcement of the Uniform Building Code and City and County regulations and policies can be effected by the above agencies by requiring the review of land use proposals and the evaluation of engineering studies for private development and public projects. Such reviews and evaluations can be performed by qualified engineering geologic and soils engineering staff or by retention of consultants.

Since alleviation of the hazard can be affected, in part, through land use controls, the agencies, departments and legislative bodies making land use decisions have the primary responsibility for alleviating the hazard. City and County Planning Departments can utilize available hazard information to avoid improper land use. Decisions concerning adoption of these recommendations rests ultimately with the Planning Commissions, City Councils and the Board of Supervisors. Other bodies making land use decisions include Port Districts and redevelopment agencies.

Present County Subdivision, Grading and Building Ordinances which are considered as strong or stronger than any in the Southern California, are adequate to insure that areas of landsliding or hillside areas

GENERAL MANAGEMENT RESPONSIBILITY

INVESTIGATION

The State Division of Mines and Geology is currently investigating geologic conditions as part of the cooperative Geologic Hazards Investigation, in those portions of the county in which development could possibly take place. The study will be completed in 1975 and will consider landslide hazards in portions of the north half, as well as the potential hazard of landsliding resulting from liquefaction of water saturated sediments during earthquake shaking in portions of the south half of the county.

Additional investigation is being conducted on a continuing basis by:

1. Private Geologic Consultants who provide original informatin during investigations for private developments.
2. Ventura County Department of Public Works which:
 - a) Provides review and evaluation of Geologic and Soils and Foundation Engineering reports prepared for private projects within the unincorporated area and for the Cities of Camarillo, Simi Valley and Santa Paula.
 - b) Performs Geologic and Soils Engineering investigations for County projects such as roads and flood control facilities.
 - c) Coordinates, evaluates, and compiles geologic information derived from public and private investigations within the unincorporated area and for the Cities of Camarillo, Simi Valley and Santa Paula.

WARNING

The potential for landsliding can be detected with relative certainty before any structures or facilities are placed in jeopardy. However, the problem is more difficult to handle in those hillside areas where development has already occurred in possibly dangerous

that could be subject to less severe landslides, but which have a definite risk slope, generally 10-15%. The Little or No Hazard Zone indicates areas which slope at less than 10% and not generally affected by landsliding. Active Beach Erosion is indicated for those areas which have, historically, been subject to severe wave erosion, which is considered a form of slope instability. Beach erosion per se, however, will be treated as a separate study within this Seismic/Safety Element. (Landslide/Mudslide Hazard Southern Ventura County.)

The Hazard Zone boundaries were primarily determined based on information provided by two recent studies of landslide conditions in southern Ventura County (conducted by the State Division of Mines and Geology for the Federal Department of Housing and Urban Development (HUD) and for the County of Ventura under a cooperative agreement). The product of the latter study was the report entitled "Geology and Mineral Resources Study of Southern Ventura County" (1973), Preliminary Report 14.

NATURE OF INFORMATION

The potential landslide areas within the county were determined mainly by aerial photographic interpretation. The information is considered good, and fairly accurate. Knowledge of many locales, especially within or adjacent to areas of urban development was gained through experience in the particular area and field checking of some areas.

The current cooperative GEOLOGIC HAZARDS INVESTIGATION being conducted by the State Division of Mines and Geology for the Ventura County area will provide additional necessary information on landslide hazards in regard to: (1) those portions of the north half of the county in which development could possibly take place and (2) areas of the southern half of the county which could be susceptible to low-angle or lateral spreading during earthquake shaking. Except for the information necessary under Item 2 above, the present information is the best form available and is considered adequate for general planning purposes. It will, however, need to be supplemented with more detailed mapping or studies for any specific proposed development.

Landslides and slope instability are widespread throughout the hillside areas. In general, most existing landslides are within the Existing Landslide Areas shown on Hazard Plate IV; most are not of recent origin, having occurred over 100 years ago, and most are not actively moving. However, they are subject to potential renewal movement if triggered by poorly planned grading, earthquakes, or if the ground moisture is increased. The areas of landsliding are, in general, confined to the areas of weak or clay bedrock and adverse geologic structure (such as bedding planes dipping in downslope directions).

Northern Ventura County

Landsliding is not believed to be of such widespread occurrence in the northern county area as to present any significant regional hazard. However, the region is extremely mountainous with steep slopes and local relief in most areas ranging from 200 to several hundred feet. Faulting and severe folding and tilting of bedrock strata is common, as are steep slopes. Another widespread condition which has contributed to formation of the present physiography and which affects the stability of hillsides is the general aggressive downcutting of stream channels.

The general, relative competence of the older bedrock throughout the region, in spite of the rugged physiography, has been the prime factor resisting the incidence of more widespread landsliding. However, many hillsides and existing landslide features are only marginally stable and only slight change in existing environmental conditions, such as would result from grading or irrigation, could trigger massive landsliding. In other words, the stability of many slopes is critically fragile and would, upon geologic investigation, show to be inadequately stable for most types of development.

DEFINITION OF THE HAZARD ZONE

Hazards Plate IV is a composite map showing landslide hazards within the southern county area. The Existing Landslide Areas designation includes area of major landslide features. The High Landslide/Mudslide Hazard zones indicate areas of marginal hillside stability which could be subject to major landslide occurrence. In general, the aforementioned categories are confined to areas containing ground surface slopes of 15% or more. Intermediate Hazard Zones are those

SECONDARY

Secondary effects of landslides can include temporary impact on society such as displaced persons and families, and possible loss of life, damage of nearby property, etc. In addition, damage suits can be initiated against original developers of the property affected by landsliding, as well as the present owners and the government agency which may have reviewed the development, approved the plans and issued the grading and/or building permits.

Other effects could include:

1. Blockage of transportation routes.
2. Disruption of utility services.
3. Blockage of drainage.
4. Loss of usable land area, etc.

GENERAL INVENTORY OF THE HAZARD

LOCATION AND HISTORY

Southern Ventura County

The widespread landsliding and slope instability throughout much of southern Ventura County can be related to a great degree to the intensity of past faulting and folding of strata and to the clay content of certain sedimentary formations, as well as to subsurface moisture content. In general, the highest propensity for landsliding is found along the more prominent fault zones, anticlinal folds and in areas of the younger geologic formations. It is also apparent that the combination of these three factors has resulted in relatively intense areas of landsliding such as along the Rincon and hillsides south of the Santa Clara River.

Landslides and potentially unstable slopes are especially common in hillside areas underlain by sedimentary bedrock of the Pico, Santa Barbara, Monterey/Modelo and Rincon Formations. These formations are generally uncemented (soft) and contain abundant silt and clay strata.

Many landslides are also associated with steep slopes which have been undercut by erosion (such as the several landslides along the easterly side of Big Sycamore Canyon northeast of Point Mugu) and downslope inclination of bedding planes (such as in the Ventura Anticline area). The presence of subsurface water is also a contributing factor to slope instability in the great majority of landslide occurrences.

GENERAL EFFECTS OF THE HAZARD

PRIMARY

Slope instability that results in landslides has caused substantial damage to the works of man in the Southern California area since the 1950's, when significant amounts of urban development first spread to the hillside areas within the County of Los Angeles. As a result of the heavy rains of 1952 there was approximately 7.5 million dollars of damage in the City of Los Angeles alone, due to erosion, deposition and landsliding. Strong hillside grading and building codes were established within Los Angeles County to prevent such future losses.

Geologic conditions similar to those within Los Angeles County also exist within the hillside areas of Ventura County. Future landsliding within Ventura County could also affect developed areas unless landslide hazard areas are recognized and appropriate land uses are designated.

In general, landsliding and the differential subsidence of the surface of landslides as well as the lateral forces exerted by most landslides can destroy most engineering structures. Most structures cannot be economically designed to withstand the forces of landsliding. Mass grading techniques have proven to be the most effective means of stabilizing landslides and unstable hillsides. This grading technique basically involves leveling of hilltops or ridges and filling in of the valleys in between, resulting in a general reduction of the height and inclination of slopes within the area.

Primary effects of landsliding can include:

1. Abrupt depression and lateral displacement of hillside surfaces over distances of up to several hundreds of feet.
2. Disruption of surface drainage.
3. Blockage of channels and roadways.
4. Displacement and breakage of utility lines (pipe and power).
5. Displacement and destruction of any improvements such as roadways, buildings, oil and water wells, etc.

were essentially parallel to the ground surface and were supported at the lower end. Once the slopes were cut, though, support was removed from the bedding surfaces.

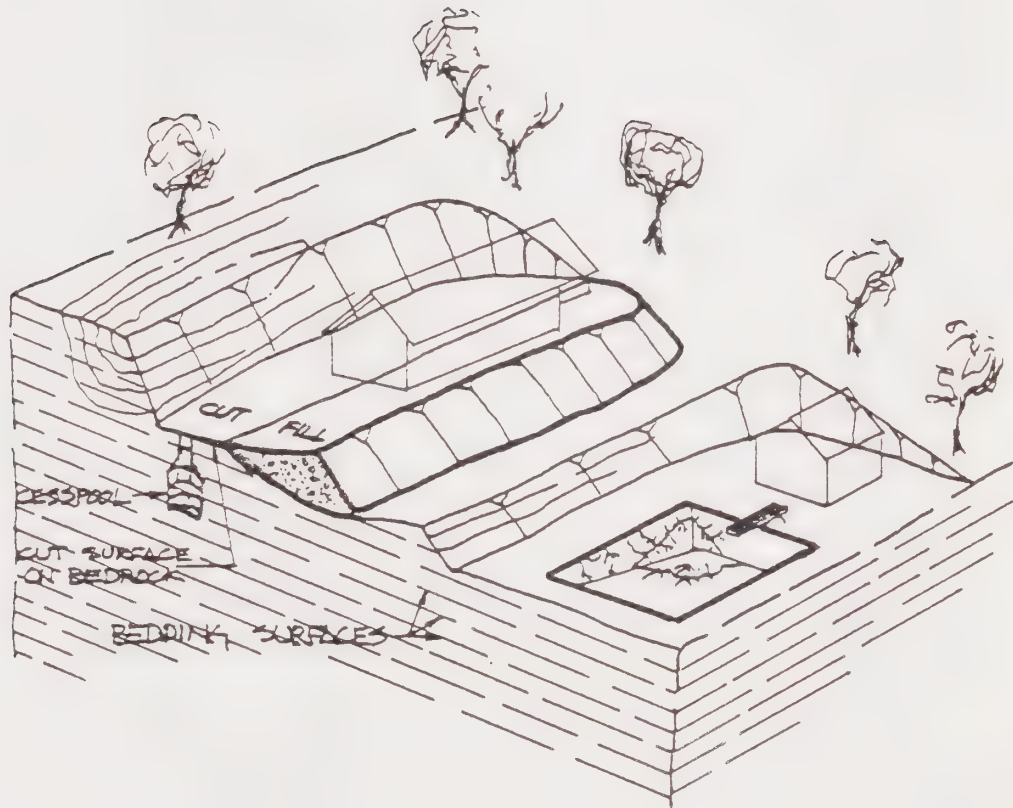
The fill in the upper residential lot of Illustration 5.5 is uncontrolled and therefore is probably poorly compacted. In this state it can settle, erode and slough without sliding en masse. Settlement can crack the foundations and walls, because the portion of the house on bedrock will not settle as much as the portion on fill.

A cut-slope in which support has been removed can fail immediately upon being excavated; or it can continue to stand for a number of years. They are the principal slopes that give way one by one during succeeding wet seasons; their ultimate failure is inevitable. The cracking illustrated in Illustration 5.5 is one of the early signs that a landslide is eminent. As the cracks widen, they serve as channelways for surface runoff which facilitates mass movement.

The best evidence that the fill was not controlled during placement is that the soil zone was not removed by proper benching. If the soil is "adobe-like" the problem is compounded. The fill prism can skid as a unit along the top of the buried soil zone; or if the fill is bonded to the soil it can fail by flowage and creep of the weak adobe zone.

Man-made slides may occur during grading operations or after grading operations in hillside development. Those that occur during grading operations are generally not as hazardous nor as expensive to repair as slides that occur after development. Slides that occur after grading are an indication that the problem was not detected during grading, that sufficient corrective and preventive measures were not taken, or that stable conditions were modified after grading (Man-Made Landslides, F. B. Leighton, 1966).

Illustration 5.5



DEVELOPMENT OF MAN-MADE BEDROCK LANDSLIDES (modified from R.H. Jahns). Hundreds of landslides in southern California are traceable to this general situation. This problem, as much as any other, has led to the adoption of grading ordinances. A naturally stable "dip-slope" has been made unstable by removing the support from bedding planes which resemble the surfaces between a tilted deck of cards. The cracking shown is one of the early signs that a landslide is imminent. Irrigation and sewage effluent contribute to slippage along the bedding.

initial failure and be broken up by the down slope spreading movement. These can continue far beyond the area in which they began and, if the movement is rapid, can move up onto the opposite side of a narrow valley.

Fourth and last, a flow is a landslide in basically unconsolidated material (Illustration 5.4). Most flows consist of saturated or nearly saturated material that undergoes viscous flow, although some types of flows are dry. Their movement is characterized by plasticity, which permits them to spread outward over wide areas and to move greater distance than other types of landslides. They often involve greater masses of material and continue downhill far beyond the base of the slope from which they originated. Many of history's most destructive landslides have been flows. Mudflows are a type of flow that are particularly prevalent after brush fires. Massively destructive mudslides hit Big Sur in 1972 after a brush fire, as they did in Glendora in 1968.

The speed with which landslides occur can vary considerably from rapid downfalls to virtually imperceptible movements downslope under the pull of gravity. Soil creep is a very slow type of earthflow movement. It occurs mainly in soils containing clay.

In general, most landslides within the county are shallow, ranging up to perhaps 100 feet in depth and limited in extent, generally less than 100 acres. Most are not presently in motion (active) but that moved downslope to positions of stability. Generally, stability is achieved within several years after the initial failure under natural conditions. However, the margin of stability of most landslides is small and inadequate to safely place structures on their surfaces.

Many of the existing landslides can be reactivated and downslope movement renewed after exceptionally heavy rainfall periods or as a result of earthquake shaking. Most landslides are over 100 years old and can exist for thousands of years until all of the landslide material is removed from the hillside by erosion.

Generally, the renewed movement of old landslides is slow, perhaps only a few inches per day. However, the formation of a new landslide can be rapid with initial, often quite sudden movements of hundreds of feet within a few hours.

Hundreds of landslides in Southern California are traceable to the general bedrock situation shown in Illustration 5.5. As long as the original natural slope remained ungraded it was stable because bedding surfaces

Illustration 5.1
Example of a Rockfall



Illustration 5.2
Slump in relatively uniform material.

Note curved slide surface.

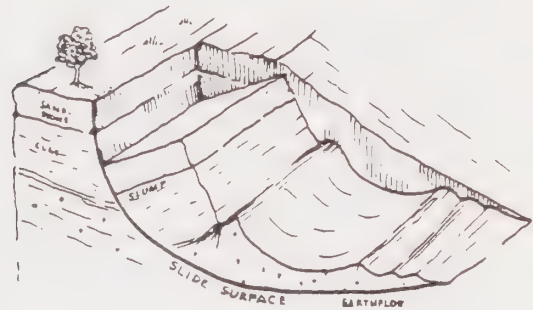


Illustration 5.3
Block-Glide in layered rocks inclined down-slope.

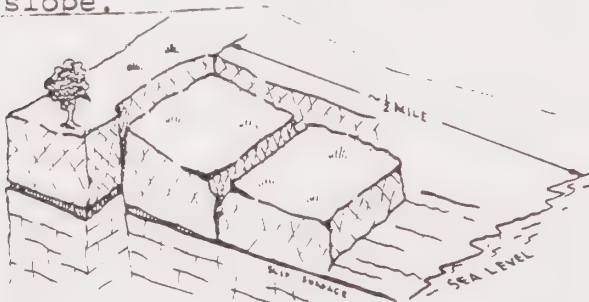
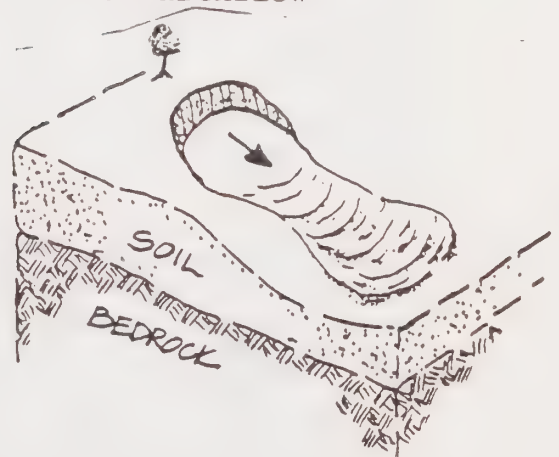


Illustration 5.4
D. Earthflow



SOURCE: Coastal Landslides in Southern California, and Ventura County Public Works.

GENERAL DISCUSSION

GENERAL DESCRIPTION

All hills, mountains and other highlands are being worn down by various natural processes. The most spectacular of these is the landslide, along with the other related types of ground failure. These processes are referred to geologically as "mass wasting", defined as: "the en masse downslope movement of rock debris" (Physical Geology, p. 134). There are numerous causes for mass wasting, including erosion, water, broken or weak bedrock, earthquakes, and engineering defects.

Stream erosion can undercut slopes thereby removing support and causing failure of slopes by landsliding.

Saturation of soil or bedrock on hillsides can reduce the strength of these materials under certain conditions to a point where downhill sliding can occur in response to gravity. Rainfall can also saturate and erode vast quantities of loose soil, especially after large fires denude slopes, washing it down slope as earth or mud flows.

Earthquakes can directly shake loose material to fall or slide downhill; it can also cause liquefaction of sub-surface materials, which also can lead to slides (see Liquefaction Hazard).

Finally, man-made cuts or excavations can undercut unstable slopes, thus causing landslides. In practice, most landslides are caused by a combination of two or more of these factors, and come in a number of forms.

First is the rockfall, which is simply the movement of all or part of a mass downslope without seriously disturbing the surface it moves over. This is most common on coastal or other types of bluffs in this area (Illustration 5.1).

More complicated are slides, which are a type of ground failure that affects both the soil and the subsoil surface. In a relatively homogeneous material the normal type of slide is a slump (Illustration 5.2). The plane of failure is usually curved and the two (the downhill end) flows out from under the surface as it rotates backwards as a unit. In a stratified, layered rock, the slide tends to be a block glide in which large masses of material move down an inclined surface maintaining their uniformity (Illustration 5.3). Both these types of slides can continue moving downslope after their

Against the wreckful siege of battering days...rocks
impregnable are not so stout.

Shakespeare

LANDSLIDE/MUDSLIDE

and require onsite waste disposal systems to be located so as to avoid impairment of them or contamination from them during flooding.

4. Require that a mention of the flood hazard be included on all deeds of sale for property in flood plain areas.
5. Adopt a policy to encourage property owners to floodproof existing structures.
6. Adopt a policy to discourage the construction of public facilities in flood plain areas.
7. Initiate the construction of major flood control projects to protect existing developments.

The requirements of paragraph (b) which are referred to in section (1) are as follows:

- (1) Take into account flood plain management programs, if any, already in effect in neighboring areas;
- (2) Apply at a minimum to all areas identified by the Administrator as flood plain areas having special flood hazards;
- (3) Provide that within the flood plain area having special flood hazards, the laws and ordinances concerning land use and control and other measures designed to reduce flood losses shall take precedence over any conflicting laws, ordinance, or codes;
- (4) Require building permits for all proposed construction or other improvements in the flood plain area having special flood hazards;
- (5) Review building permit applications for major repairs within the flood plain area having special flood hazards to determine that the proposed repair (i) uses construction materials and utility equipment that are resistant to flood damage, and (ii) uses construction methods and practices that will minimize flood damage;
- (6) Review building permit applications for new construction or substantial improvements within the flood plain area having special flood hazards to assure that the proposed construction (including prefabricated and mobile homes) (i) is protected against flood damage, (ii) is designed (or modified) and anchored to prevent flotation, collapse or lateral movement of the structure, (iii) uses construction materials and utility equipment that are resistant to flood damage, and (iv) uses construction methods and practices that will minimize flood damage;
- (7) Review subdivision proposals and other proposed new developments to assure that (i) all such proposals are consistent with the need to minimize flood damage, (ii) all public utilities and facilities, such as sewer, gas, electrical, and water systems are located, elevated, and constructed to minimize or eliminate flood damage, and (iii) adequate drainage is provided so as to reduce exposure to flood hazards; and
- (8) Require new or replacement water supply systems and/or sanitary sewage systems to be designed to minimize or eliminate infiltration of flood waters into the systems and discharges from the systems into flood waters,

OPTIONS

The following are a variety of alternative responses or "options" to the hazard. The appropriateness of each option will depend upon the specific conditions spelled out in the FINDINGS section.

1. Designate undeveloped flood plains as open space in the General Plan.
2. Adopt the 100-year flood as defined by the Ventura County Flood Control District as the selected flood for flood plain regulation.
3. Adopt the land use and building controls contained in the National Flood Insurance Regulations.

The regulations require different measures depending on the amount of information available. The identified flood plain areas in Ventura County would be included in category (c):

(c) When the Administrator has identified the flood plain area having special flood hazards, and has provided water surface elevations for the 100-year flood, but has not provided data sufficient to identify the floodway or coastal high hazard area, the minimum land use and control measures adopted by the community for the flood plain must -

(1) Meet the requirements of paragraph (b) of this section;

(2) Require new construction or substantial improvements of residential structures within the area of special flood hazards to have the lowest flood (including basement) elevated to or above the level of the 100-year flood;

(3) Require new construction or substantial improvements of non-residential structures within the area of special flood hazards to have the lowest flood (including basement) elevated to or above the level of the 100-year flood or, together with attendant utility and sanitary facilities, to be floodproofed up to the level of the 100-year flood; and

(4) In riverine situations, provide that until a floodway has been designated, no use, including land fill, may be permitted within the flood plain area having special flood hazards unless the applicant for the land use has demonstrated that the proposed use, when combined with all other existing and anticipated uses, will not increase the water surface elevation of the 100-year flood more than 1 foot at any point.

FINDINGS

PROBABILITY OF OCCURRENCE

Floods are natural occurrences whose frequency and magnitude depend on the rainfall and drainage patterns. It can be expected that the flood plain will probably be completely inundated on the average of once every 100 years.

SEVERITY OF THE HAZARD

Several areas in the county are subject to serious flooding. Past floods indicate that loss of life, property damage and loss in economic production could be extensive. In addition, funding for flood damage is limited and is costly to the public in general.

RESOURCES AFFECTED

Located within the 100 year flood plain of the Ventura River and the Santa Clara River are residential areas such as portions of Live Oak Acres and Casitas Springs. The remaining unincorporated areas are in agriculture or open space uses. Along the Calleguas Creek flood plain, besides agriculture and open space uses, are two schools and a sewage treatment plant.

NATURE OF THE INFORMATION

Existing data is sufficient to calculate the overflow for specific areas. In addition, the Flood Control District has begun a 5-year study to map the floodway limits (designated watercourses) for rivers and major tributaries.

OTHER FINDINGS

The most appropriate uses for flood plains are open space uses, such as greenbelts, parks and some types of agriculture. Where development is permitted, however, it should be controlled through more specific and stricter regulations than are now in effect.

LOCAL DISCUSSION

LOCAL INVENTORY OF THE HAZARD

The county's three rivers and all of their major tributaries, as well as many smaller channels, are located in unincorporated areas over much of their courses. The presently mapped flood plains are shown on Hazard Plate III.

LOCAL RESOURCES AFFECTED BY THE HAZARD

Located in the 100-year flood plain of the Ventura River are the communities of Live Oak Acres and Casitas Springs and a small settlement northwest of Meiners Oaks. In addition, there are main sewer and water lines along much of the length of the Ventura River and San Antonio Creek. Most of the rest of the Ventura watershed hazard area is in open space or agriculture. The unincorporated parts of the Santa Clara watershed flood plain are primarily in agriculture, with some open space and industrial areas. Virginia Colony and most of the community of Moorpark including residential, commercial, and individual areas, two schools, a sewage treatment plant, and sewer and water lines, are located in the Calleguas Creek flood plain. The other county areas in the Calleguas Creek watershed flood plain are mainly agricultural or vacant.

LOCAL MANAGEMENT RESPONSIBILITY

The County Planning Commission and Board of Supervisors have the authority to alleviate the flood hazard through land use and building regulations.

Existing regulations are contained in the Subdivision Ordinance and Building Code, which require that buildings and improvements be protected from flood damage. This provision is enforced by the Planning and Building and Safety Departments based on the recommendations of the Flood Control District. The standard condition imposed on development is that the homes be protected (by elevation, channel improvement, dikes, or flood-proofing) from the Flood Control District's identified 50-year flood.

the effect of increasing downstream flood peaks and velocities and may contribute to beach erosion by reducing the amount of sand reaching the beaches. (Norris, R.M., p. 154)

Preventive measures for alleviating the hazard include public acquisition of flood plain lands, public information program, development policies, and regulations. The most effective means of preventing flood damage appears to be the regulation of the types of activities permitted in flood hazard areas. This approach is generally referred to as flood plain management. Flood plain management addresses the problems encountered in the utilization of flood plains; given the possible future land uses, the total spectrum of possible solutions to problems is considered. Flood plain management however, cannot protect all existing development. Therefore, to provide for the maximum alleviation of the flood hazard, a combination of corrective and preventive measures is necessary.

The Colbey-Alquist Flood Plain Management Act requires regulation as a condition for state assistance on federally authorized flood control projects.

The regulations of the National Flood Insurance Program (administered by the Department of Housing and Urban Development) require that communities adopt land use restrictions normally for the 100-year flood plain, in order to qualify for federally subsidized flood insurance. The types of restrictions communities must adopt are listed in some detail in the regulations; included is a requirement that residential structures be elevated above the level of the 100-year flood (see page for excerpts). Participation in the flood insurance program was recently made virtually mandatory by an amendment making flood insurance (in identified "special flood hazard" areas) a prerequisite for receiving mortgages or construction loans from federally regulated lending institutions. Although the county and all of the cities except Ojai are now on the eligible list for the program, most of these entities have not fully met the requirements considered optimal by the Federal Insurance Administration. It is highly probable that these entities will be required to upgrade their land use ordinances and regulations in the future in order to qualify for continuance in the National Flood Insurance Program.

WARNING

Flood warnings, issued by the U. S. Weather Bureau or the Flood Control District, are relayed to the public through the local news media and Sheriff's and Police departments.

ALLEVIATION

The flood hazard may be alleviated through a variety of measures, some corrective and some preventive.

Corrective measures include warning and relief programs, flood proofing of existing structures, and the construction of flood control works (channel improvements, levees, and dams). Structural works are the traditional means of alleviating the hazard, but they are extremely costly and are rarely able to keep up with development. Nationally, a half billion dollars a year is spent on flood control works, while flood damages average one billion dollars a year and are increasing. (Kusler, p. 3 and Sierra Club, p. 59). The cost of structurally protecting all the channels in the county Flood Control District's comprehensive plan has been estimated at over 300 million dollars, (V.C.F.C.D., the Great Floods of 1969, p. 2). Improperly planned structural works may also have

Floodway limits, which are extremely important for flood plain planning, have not yet been delineated for any channels in the county. However, the Flood Control District has begun a 5-year program of mapping flood plains and will soon begin to compute floodway limits (referred to as "designated watercourses") for the rivers and major tributaries. The computation and designation of floodways for all channels under the District's jurisdiction will take many years.

GENERAL MANAGEMENT RESPONSIBILITY

INVESTIGATION

The Flood Control District has collected some data on flood discharges and topography and will soon begin delineating flood plains and floodways. At the request of the District, the Army Corps of Engineers has prepared Flood Plain Information Reports for eight major stream reaches in the county. These reports contain information on flood history and detailed maps and information on theoretical future flood profiles (heights) and corresponding overflow limits.

REGULATION

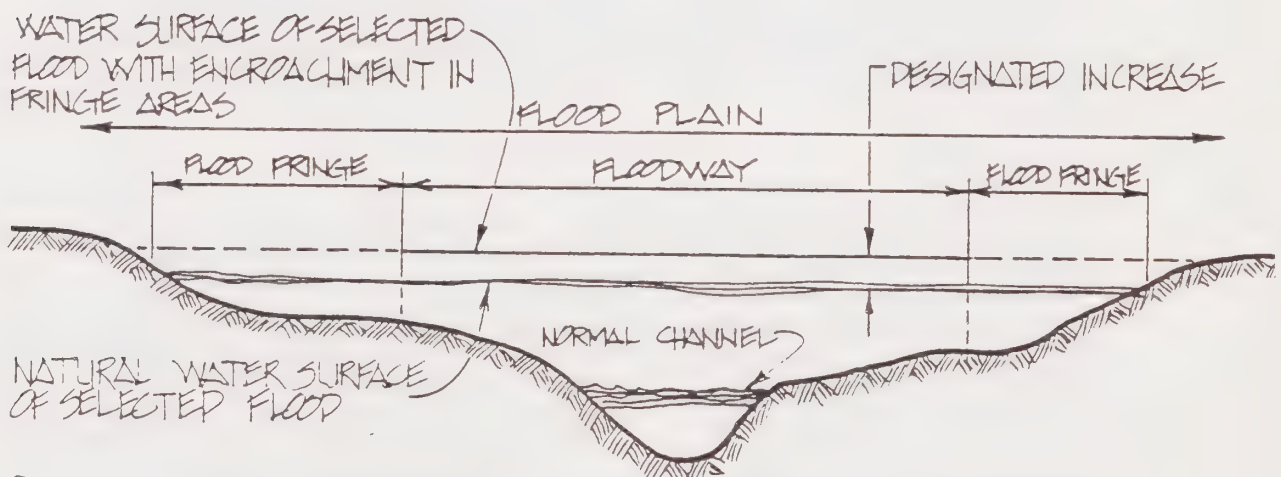
The entities responsible for regulation in flood hazard areas are the local governments and the Ventura County Flood Control District. The Flood Control District, which is governed by the Board of Supervisors, has the authority to maintain and construct flood control facilities on the channels shown on Hazard Plate 3. Ordinance FC-18, adopted in 1972, requires that a permit from the Flood Control District be obtained for most activities in "designated watercourses". At present, "designated watercourses" refers only to the bed and banks of the channels but once the floodways are mapped and public hearings are held, a portion of the overflow area inundated by a selected flood will be controlled by the Ordinance.

Outside of the designated watercourses, the prime responsibility for regulating activities in flood hazard areas lies with local governments. By State law land use and building restrictions to protect life and property from floods may be included in zoning and subdivision ordinances and building and sanitation codes. State and federal legislation has sought to encourage local governments to establish regulations for flood plains.

All presently available information on the geometrics of flood plains in the county is shown on the Hazard Plate. The 100-year and standard project flood plains of the Santa Clara and Ventura Rivers, Calleguas Creek (including Arroyo Simi), and Santa Paula, Sespe, San Antonio, and Conejo Creeks have been mapped by the Corps of Engineers. The U. S. Soil Conservation Service has mapped the 50-year flood plains of Revolon Slough. Flood plain limits for the other tributary channels have not yet been mapped. Many of these tributaries have flood control improvements over at least part of their courses.

The flood plain may actually be divided into two hazard areas: (1) the floodway, which is the portion that carries the deep and fast-moving water (usually defined as the area needed to contain the flood, allowing for a designated increase in flood height); and (2) the flood fringe area, which is the remainder of the flood plain.

Illustration 4.1. Flood Plain



Source: County Department of Public Works

NATURE OF INFORMATION

Flood plain limits are calculated from the best topographical information and hydrologic and hydraulic data and assumptions available. These delineations reflect existing conditions and changes in topography or land uses could affect these limits. Although the flood plains of many of the watercourses in the county have not been mapped, the Flood Control District has the capability to calculate the overflow areas for specific locations.

The largest and most damaging recorded natural floods in the Calleguas Creek, Santa Clara, and Ventura watersheds occurred in 1969. (The St. Francis Dam failure in 1928 caused the largest known flood on the Santa Clara River). In 1969 the 50 and 100-year peak discharges were exceeded in many channels. The combined effects of the 1969 floods were disastrous: thirteen people lost their lives and property damage was estimated at 60 million dollars. Homes in Casitas Springs, Live Oak Acres, and Fillmore were flooded and 3,000 residents in Santa Paula and several families in Fillmore were evacuated twice. A break in the Santa Clara levee threatened the City of Oxnard. Much agricultural land, primarily citrus groves, was seriously damaged. All over the county transportation facilities, including roads, bridges, and railroad tracks, were damaged. There was several million dollars worth of damage at the Ventura Marina. The Fillmore, Oak View, and Ventura sewage treatment plants were severely damaged, dumping raw sewage into the Santa Clara and Ventura Rivers and polluting beaches. In addition, sewer trunk lines were broken along San Antonio Creek, the Ventura River, and Calleguas Creek.

DEFINITION OF THE HAZARD ZONE

The boundaries of the hazard zone depend on the magnitude of peak discharge chosen for the selected flood. The Ventura County Flood Control District and most of the cities in the county use a 50-year flood as the selected flood, while the National Flood Insurance Regulations and most flood plain management literature use a 100-year flood. The Corps of Engineers has delineated 100-year (intermediate regional) and standard project floods (the largest flood that can reasonably be expected to occur).^{*} For this study the Corps of Engineers 100-year flood plain is used as the hazard zone on the streams for which it has been mapped. (See Hazard Plate III)

^{*} The Flood Control District and the Corps base their calculations on different assumptions of watershed development and therefore get different results for flood magnitudes and overflow areas. The District is presently conducting a study of the comparative magnitudes of the various floods to determine whether there is a significant difference between their 50-year flood and the Corps' 100-year flood.

the severe erosion which results from fast-moving flood waters. Serious damage can also be caused by the floating debris and sediment carried by flood waters. Floating debris (including parts of buildings, trees, etc.) can obstruct the flood flow, resulting in increased flood heights and overflow areas. Debris can also damage structures and bridges, and can damage or plug flood control channels. Mineral and organic debris and sediment deposited on the land as the flood waters recede create a huge cleanup problem and health hazard and can destroy crops and croplands.

Floods may also create health hazards due to the discharge of raw sewage from damaged septic tank leach fields, sewer lines, and sewage treatment plants and due to flammable, explosive, or toxic materials carried off by flood waters. In addition, vital public services may be disrupted.

A major secondary effect of flooding is the cost to local and national taxpayers. Evacuation, relief, and floodfighting services, cleanup operations, and the repair of damaged public facilities are all paid for by the public. Taxpayers must also bear a share of the cost of federal loans for reconstruction of private property and of damage claims under federally subsidized flood insurance. Another large expense arises from the construction and maintenance of flood control facilities to protect development from future floods.

The duration and extent of the hazard depend on the specific physical characteristics and conditions of the watershed and the intensity and duration of the storm. Generally, in Ventura County a flood builds up to a peak and then begins to recede, with the entire process lasting from an hour to a week, depending largely upon the size and slope of the watershed.

GENERAL INVENTORY OF THE HAZARD

Damaging floods at some locations in the county were reported as early as 1862; other floods were reported in 1884, 1889, 1911, 1914 and 1916. Floods for which data was recorded occurred in 1932, 1933, 1934, 1938, 1941, 1944, 1946, 1950, 1952, 1958, 1962, 1965, 1966, 1967, January 1969 and February 1969.

GENERAL DISCUSSION

GENERAL DESCRIPTION

A flood may be defined as a "temporary rise in stream flow or stage that results in water overtopping its banks and inundating areas adjacent to the channel." (Kusler, p. 54). The area subject to inundation is generally referred to as the flood plain. The size and frequency of occurrence of a flood in a particular channel depends on a complex combination of conditions, including the amount, intensity, and distribution of rainfall, previous moisture conditions, and drainage patterns.

The magnitude of a flood is measured in terms of its peak discharge, which is the maximum volume of water (in cubic feet per second) passing a point along a channel. However, floods are usually referred to in terms of their frequency of occurrence, which is related to discharge; for example, the 100-year flood for a particular channel is the size flood which has a probability of being equalled or exceeded once in 100 years. The magnitude of the flood selected by a governmental agency for planning purposes (usually 50-year or 100-year) is referred to as the selected or regulatory flood.

Flooding is a natural occurrence, with some long range beneficial aspects such as replenishment of sand to beaches and of nutrients to agricultural lands. It is a hazard only because people find flood plains a desirable place to live and use. Man's encroachment on flood plains can also increase the hazard: structures may obstruct the flood flow, thus increasing flood heights, and the covering of the ground with impervious surfaces (e.g. pavement) increases the rate and quantity of runoff.

GENERAL EFFECT OF THE HAZARD

The primary effect of flooding is the threat to life and property. People and animals may drown; structures and their contents may be washed away or destroyed; roads, bridges, and railroad tracks may be washed out; and crops may be destroyed. The amount of damage caused by a flood depends on the depth of inundation, the velocity and duration of the flood, the debris production of the watershed, and the erodibility of the bed and banks of the watercourse.

Much of the property damage from floods is caused by

Nothing under heaven is softer or more yielding than water, but when it attacks things hard and resistant there is not one of them that can prevail.

Tao Te Ching

240 B.C.

are adequately investigated and that any development incorporates appropriate design provisions to prevent landsliding. The Departments of Public Works and Building and Safety of both the County and Cities have the responsibility of adequately enforcing these or equivalent ordinances.

LOCAL DISCUSSION

LOCAL INVENTORY OF THE HAZARD

Almost all sites with potential for landsliding lie within the hillside and coastal areas of Ventura County. Most existing landslides are in remote areas and have resulted from the natural processes or erosion, soft bedrock, ground moisture, steep topography, geologic structure and earthquakes. Many were formed prior to historic time.

Since the advent of grading equipment and the continuing development of valleys and plain areas, hillside and coastal areas in Southern California have come under increasing pressure for urban development. As a result, man's activities involving cutting, filling, drainage diversions, irrigation, use of on-site sewage disposal systems and stripping of vegetation from slopes have also become a major factor in the formation of new landslides and the reactivation of previously stable ones.

Fortunately, the greatest pressures for hillside development have occurred in areas outside of the county. The experience gained in these areas should result in avoidance of occurrence of major, man-caused, landsliding in the hillside areas of Ventura County.

Approximately 75% of the total area of Ventura County can be considered as mountainous or hillside area. Even the southern half of the county, which includes the Oxnard Plain, consists of about 60% hillside or ground sloping at more than 27° (15%).

Since most of the presently developed areas lie outside of the areas of potential landsliding in hillside areas, the present county-wide hazard can be considered low. However, the hazard can increase as more development occurs in hillside areas unless adequate geologic investigation of hillside areas are conducted and stability considerations are incorporated in development plans.

RESOURCES AFFECTED BY THE HAZARD

Development has extended on to some hillside areas within the county. Much of this development occurred prior to establishment of many of the present ordinance

requirements concerning evaluation of hillside stability and incorporation of design provisions to safeguard against landsliding. Most of this development has involved single family residential subdivisions. Up to now relatively few landslides have occurred in areas which have affected structures.

The extent of development within potential landslide hazard areas can be determined by comparison of Hazard Plate IV with a land use map. Although many residential areas and utility facilities are within these zones, on the basis of present information, it cannot be concluded that any of the structures or facilities are in immediate danger.

FINDINGS

PROBABILITY OF OCCURRENCE

Landsliding can be considered a major hazard in any hillside area and the hilly and mountainous areas of Ventura County are no exceptions. However, experience gained from intensive development and urbanization of many of the hillside areas of regions adjacent to the county should provide ample warning of the destruction that can and will occur from landsliding. Most destructive landslides have resulted from the indiscriminate development of sloping ground or creation of cut and/or fill slopes in areas of unstable or inadequately stable geologic conditions. Most of the failure could have been prevented by recognition of potentially unstable conditions through adequate investigation and incorporation of design safeguards prior to grading or construction.

The hazard of landslides, however, is not always confined to areas commonly considered hilly or mountainous. Under certain soil and ground moisture conditions landsliding can occur in areas of newly level ground. This was clearly demonstrated by landsliding triggered during the San Fernando Earthquake of 1971 which resulted in destructive lateral ground movement over large areas with regional slopes of as little as one and one-half percent. Conditions which could result in similar lateral spreading or low-angle landsliding may also exist in some areas of Ventura County.

SEVERITY OF THE HAZARD

The hazard from landsliding is considered to be real within the areas of the county which were developed prior to present day Grading and Building Codes. The level of hazard cannot readily be determined without detailed investigation of individual sites. This is considered to be the responsibility of the individual property owner.

RESOURCES AFFECTED

Since the primary land use within hillside areas aside from unurbanized uses, is residential, the hazard primarily impacts dwellings and the associated utility facilities. The level of hazard is unknown as

geologic information of sufficient detail for specific developed areas is not available.

NATURE OF THE INFORMATION

The present information is the best available and is considered adequate for general planning purposes. It will, however, need to be supplemented with more detailed mapping or studies for any specified proposed development.

OTHER FINDINGS

Existing landslides should be recognized and, in general, their surfaces and immediate adjacent areas should not be developed. However, if explored in detail, it may be feasible to stabilize some of these features by buttressing, etc., and thereby utilize their surfaces for some form of appropriate development.

Land development of hillside areas could, of course, result in formation of new landslides if the grading or development design in hillside areas does not continue to take into consideration potentially adverse conditions which may exist in areas presently unaffected by landsliding. Many of the natural slopes are underlain by bedded sedimentary rocks that are inclined in downslope directions. The slopes in these cases are marginally stable and prone to failure along the bedding planes. Uncontrolled grading or introduction of irrigation or on-site sewage disposal in areas underlain by ancient landslides could trigger renewed movement.

Extensive grading of the mountainous area as would be necessary for high density development is considered practical only by gross leveling of large areas by daylighting ridges, filling valleys, and minimizing slope heights and inclinations to avoid large scars. In general, a road grading only concept, except where possible to avoid cuts and fills over 20 to 30 feet in height and slopes steeper than 2:1, is not considered desirable because of resulting highly erodible cut and fill slopes and the high cost of slope maintenance.

Most areas of landslides and adjacent marginally stable slopes will not be economically feasible to develop because of the massive grading necessary to effect stability. Landslide areas or areas having the higher propensity of landsliding should not be considered as developable unless mass grading techniques involving filling of canyons and gross leveling of hillsides is

anticipated. Only the smallest landslides can generally be stabilized to allow development of their surfaces. Stabilization of large slides is generally too expensive, in most cases, to be feasible.

In general, high density subdivision development of hillside areas within the county is considered practical only by gross leveling of hillsides and filling of valleys and thereby eliminating both high and steep natural slopes, as well as the need for high or steep graded slopes. Presently, however, this will only be feasible in the lower hillside areas. Most areas of high relief and/or landsliding will not be economically feasible to develop because of the massive grading necessary to effect stability.

Development of County Subdivision and Grading Ordinances, land development policies and building codes over the past several years has progressively resulted in greater public safety. The requirements are considered equivalent to, or exceed those of, other counties in California. The present requirements are considered adequate to insure that areas of landsliding or areas prone to landsliding are not indiscriminately developed and that adequate measures are incorporated in grading and building design to insure that landsliding will not occur.

Little is known of the potential of landsliding or lateral ground movement resulting from liquefaction in Ventura County. However, some areas may have conditions conducive to this type of hazard. They are the areas along the beach from Point Mugu to the Ventura River, including areas adjacent to harbors, marinas and sea level channels, and inland between Seaward Avenue and Ventura River.

OPTIONS

The following are a variety of alternative responses or "options" to the hazard. The appropriateness of each option will depend upon the specific conditions spelled out in the FINDINGS section.

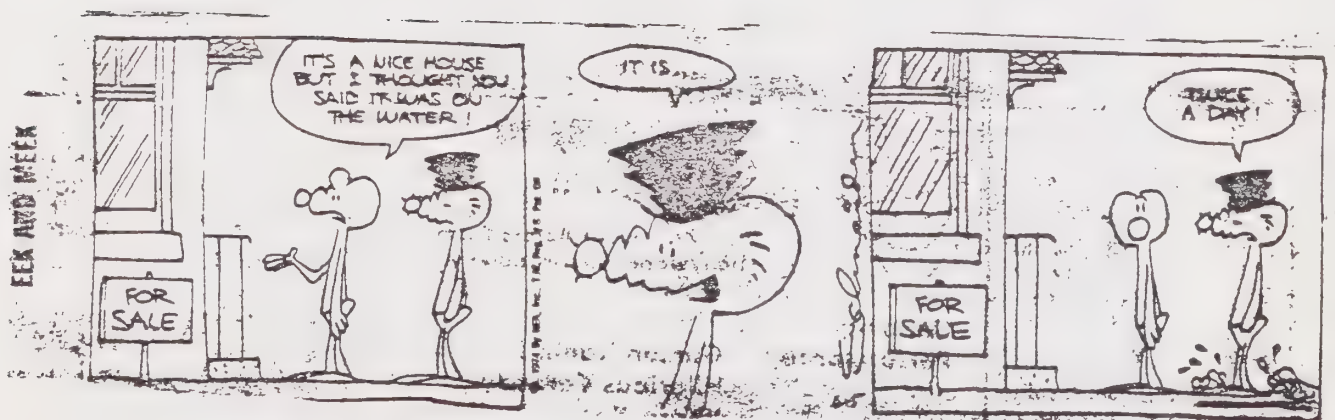
1. Require that any proposed development within the Existing Landslide Areas or areas of High or Intermediate Hazard indicated on Hazards Plate IV be shown to be feasible by completion of engineering geologic and soils engineering studies, including recommendations for safe development, prior to approval of proposed land uses. Such studies should also be required, as necessary, in other areas.
2. Require that any proposed development within the Existing Landslide Areas or areas of High or Intermediate Hazard indicated on Hazards Plate IV be evaluated by qualified personnel retained by the local agency to determine if engineering geologic or soils engineering feasibility studies are necessary prior to approval of proposed land uses.
3. Consider all Existing Landslide Areas and High Landslide/Mudslide Hazard Areas to be unsuitable for permanent development unless adequate engineering geologic and soils engineering investigations are performed and appropriate safeguards are implemented in design. Agricultural uses may be satisfactory in these areas where any new or renewed landsliding would not directly or indirectly affect any other public or private property.
4. If necessary, retain private consultants for more detailed determination and study of potential hazards.
5. Adopt current Uniform Building Code and the additional provisions of the County Subdivision Ordinance, Building Regulations and the Land Development Manual or equivalent requirements for all land development.
6. Provide adequate enforcement of the aforementioned requirements by requiring that each proposal for land development and reports and plans submitted be reviewed by qualified personnel registered and certified by the State such as professional engineers, soils engineers and engineering geologists.
7. Achieve adequate enforcement through establishing qualified staff or retaining private consultants or county services on an as-needed basis.

8. Adopt current investigation guidelines for proposed land development within the Primary or Secondary Fault Hazard Zones and for all major projects such as those published by the State Division of Mines and Geology and by the Structural Engineers Association of Southern California (Technical Appendix).

BEACH EROSION

I have seen the hungry ocean gain
Advantage on the kingdom of the shore
And the firm soil win of the watery main
Increasing store with loss, and loss with store.

Shakespeare



GENERAL DISCUSSION

GENERAL DESCRIPTION

The erosion of coastal beaches is a very complex and multi-faceted problem. It arises from many factors comprising the coastal ecosystem. Simplistic and short-sighted solutions are inadequate to deal with the beach erosion problem because it is such an intricate and dynamic phenomenon. Only long-range, comprehensive, technically informed approaches can effectuate a complete and long lasting solution.

PHYSICAL PROPERTIES

The beach is an ever changing entity. It is in a perpetual state of dynamic disequilibrium, adjusting to changes in waves, currents, tides and sediment deposition. These agents create a flow of sand along the coastline known as the littoral drift. Beaches remain stable only when the amount of sand deposited is equal to the amount of sand taken away, both of which are determined primarily by the littoral drift. Since these two factors only rarely negate each other exactly, beaches are usually either receding or advancing at any one point in time.

Sandy beaches are formed largely by the weathering of inland rocks and riverine transport to the sea. The sand which maintains Ventura County beaches travels with the littoral drift from north to south, originating almost entirely from the Santa Clara River when in flood (70%) the Ventura River (10%) and from beaches up coast of the Ventura River (20%), totaling a movement on the average of 1.2 million cubic yards of sand per year between the Santa Clara River and Port Hueneme (Southern California Coastal Water Research Project, March, 1973). This sand is part of the Santa Barbara littoral cell. A littoral cell is a closed system of shoreline in which sand undergoes a complete transport cycle. It begins typically with a stretch of rocky coast where the sand supply is extremely limited. Downcoast, in the direction of the littoral drift, sand supplies become more abundant and the beaches become straighter and wider. The cell is terminated by submarine canyons or other "sand sinks" which capture sand and halt its movement, thus causing another littoral cell to begin with rocky coasts devoid of beaches (California Coastal Zone Conservation Commission, April, 1974). In the Santa Barbara cell, most of the sand terminates in the Mugu and Hueneme submarine canyons.

The force which moves sand along the shoreline, creating the phenomenon known as the littoral drift, is provided by waves breaking at an angle along the beaches. Since a component of the wave energy imparted to the beach is along the shoreline, and consistently in the same direction, the net effect of many such waves is to push sand steadily alongshore. In Ventura County, waves moving in the direction of prevailing westerly wind generally do meet the beaches head on, because of the shoreline's orientation from northwest to southeast. The resultant effect is a net movement of sand over time from north to south along the beaches.

In addition to the littoral drift, there is an onshore-offshore movement of sand. Waves which are small or spaced far apart tend to move sand from the ocean bottom towards the beach, building it out. Large, closely spaced waves tend to cut back the beach and move the eroded sand seaward, forming sand bars in shallow water. In the absence of littoral drift, beach motion is merely an exchange of sand moving back and forth between beach and bar in response to changing weather patterns. (Bascom, 1964).

ORIGINS

Natural Processes - As mentioned above, large, closely spaced waves tend to move sand from onshore to offshore. Also, large waves move sand at a faster rate alongshore than small waves (Bascom, 1964). Therefore, during periods of increased wave activity, the waves pounding the beaches can cause the coastline to dramatically recede, since more sand is taken away than is deposited. Major storms have caused erosion up to 100 feet on many U.S. beaches (Perm. Int. Asso. of Nav. Cong., 1973). Such recession is even greater when storms are combined with periods of high tides. This effect greatly elevates the ocean level since storms themselves cause the tide to elevate (a phenomenon called "storm surge").

Sandy beaches, formed largely by the weathering of inland rocks and riverine transport to the sea, often serve as a natural buffer between the sea and the easily erodible upland. A highly eroded beach loses some of its protective capability. A wide flat beach just above the waterline permits many of the oncoming waves to dissipate without damage, when the same waves would produce intensive damage in a region fronted by a narrow, eroding beach. A continuous dune line can likewise limit the area of wave damage to the ocean front by providing another line of defense against damaging waves; but the beaches and dunes are both subject to erosion by prolonged wave attack and areas that appeared safe at the beginning of a storm may be in danger if the storm surge persists through two or more high tides (U.S. Water Res. Council, August, 1971).

Southern California's coastline experiences relatively high levels of both wave activity and coastal sedimentation. Therefore, large changes in either factor relative to the other can result in rapid changes in coastal profile, since beach stability is dependent primarily upon a balance between these two factors (So. Calif. Assoc. of Govts., February, 1972). In fact, large changes in both do occur due to Southern California's highly variable weather. The sediment which is produced from storm related floods may take months, or even years, to find its way to the beaches and undo the immediate damage of the storm activity. Despite rapid changes, continuance of the beach over a long period of time is assured with an adequate supply of replenishing sand.

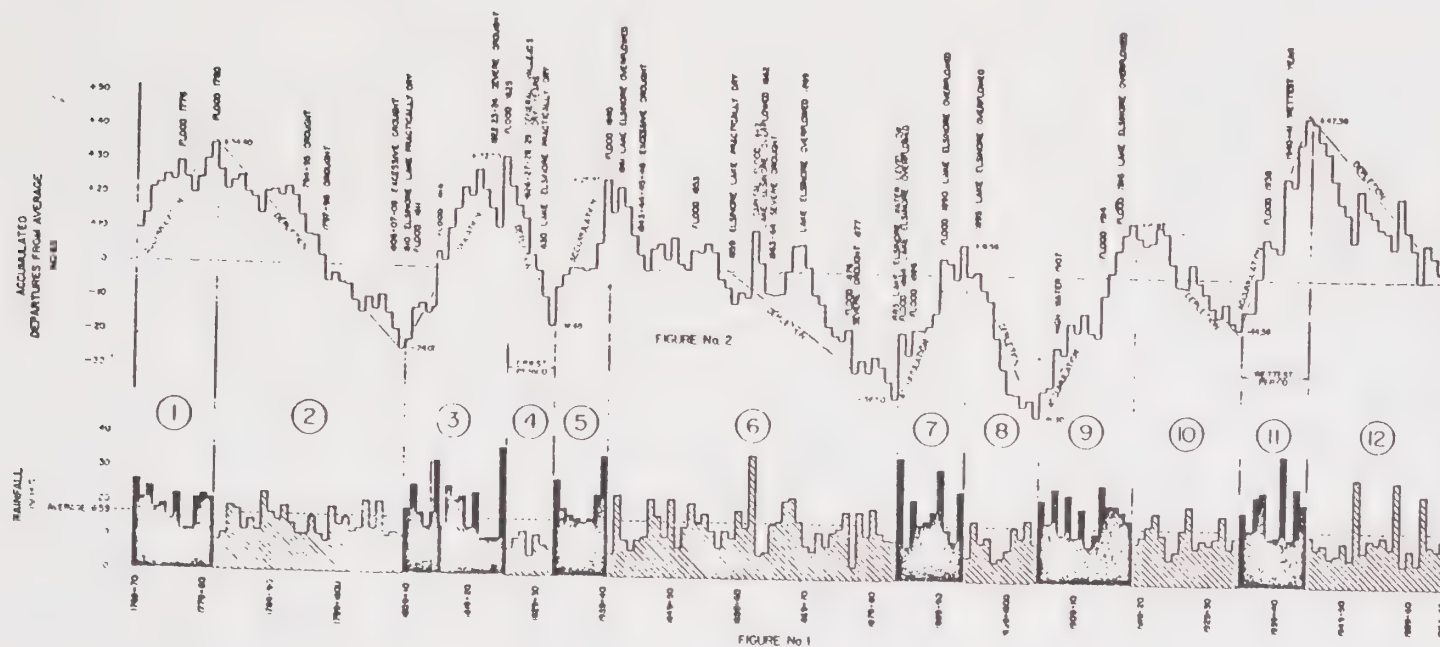
Coastal erosion in Southern California has seasonal trends and other natural cycles in addition to the dramatic fluctuations which occur from heavy storms. The beaches can change from month to month in response to tidal fluctuations, and generally advance in the summer months, which have moderate wave activity, and recede during the rest of the year in response to increased wave activity (So. Calif. Assoc. of Govts., March, 1973). Some beaches have, in addition, even longer cycles of beach erosion. California's weather runs wet and dry in cycles of about 25 years, corresponding roughly to the double sunspot cycle that affects all of earth's weather. In a dry cycle, relatively little sediment gets washed into the sea (Soucie, June, 1973). Most of the sediment input occurs during the large, infrequent floods (So. Calif. Coastal Water Research Project, March, 1973). Therefore, a net long-term erosion trend should occur in dry cycles, which have few if any large floods.

Illustration 6.1 depicts seasonal rainfall fluctuations at Santa Paula from 1769 to 1965, dividing the trends into wet and dry periods. Since there were six cycles during this period, the cycles run roughly 32 years, somewhat longer than the stated 25 year cycle. Nevertheless, it substantiates the existence of a long term cyclical pattern of rainfall to which a pattern of erosion should generally correspond. The relationship between rainfall and coastal deposition of sediment was elucidated by an Army Corps study in Santa Barbara Harbor, which showed that a graph of rainfall plotted by 2-year totals had a striking similarity to a graph of accretion of 2-year intervals when the time factors were adjusted to show accretion lagging 3-1/2 years behind rainfall (U.S. Congress, December, 1948).

It is possible that superimposed on natural cycles of erosion, where they occur, are very long-term trends of net shoreline change stemming also from natural processes. General states of shoreline progradation (built out) or

Illustration 6.1

Estimated Seasonal Rainfall at Santa Paula 1769-70 to 1871-72
Measured Seasonal Rainfall at Santa Paula 1872-73 to 1964-65
196 Year Average 16.55"



retrogradation (erosion) could be caused by such agents as geologic uplift or subsidence, climatic shifts, and a fluctuating sea level (some authorities believe the sea level has been rising 1 to 2 feet every century) (Perm. Int. Assoc. of Nav. Cong., 1973). Long-term trends which are more localized can be caused by river migration, near-shore wave energy alteration, and the presence of headlands. River migration changes the location of river deltas, which act as groins by catching littoral sediment, thereby causing accretion on the upcoast side and inducing erosion on the downcoast side because of the reduced littoral flow. The wave energy which actually reaches the shoreline at various points is influenced by nearshore wave refraction and ocean bottom configuration. These factors have the ability to influence the erosive capability of waves reaching the beach, and hence create a alternating erosion and accretion zones (Munk, January, 1947). Headlands which jut out into the water also act as groins. Hence, the bare rock of headlands on their down current sides often erodes away continually because the flow of sediment is captured by the headlands on their updrift sides.

Man-Induced Processes - Like nature, man has the ability to alter the configuration of the shoreline by inducing long-term or short-term erosion. His method is to interfere with natural processes, and his motivation is usually to prevent or impede natural fluctuations in the shoreline. However, sometimes his works are meant to correct problems of his own doing. These problems may stem from short term solutions to other erosion problems, or from projects ostensibly unrelated to the beach.

The construction of groins, jetties, seawalls, and breakwaters are the primary structural measures used to impede beach erosion. Each is at best a partial, short-term solution to erosion problems. Groins, for example, can trap littoral sand and build beaches out over a certain area, but by doing so they reduce for a time the amount of sand that flows to downcurrent beaches and, therefore, may relocate the original problem by causing erosion in other areas. Breakwaters and jetties (which are typically employed to protect harbors from wave activity) have similar downcurrent effects on the littoral drift of sand, although the mechanics are different. Since jetties are longer than groins, they interfere with sand flow to a greater degree, and sand bypassing is usually required to replenish downcurrent beaches. Seawalls can provide a "line of defense" for homes against the onslaught of waves, but tend to reflect the energy of the waves backward, which gouges out sand seaward of the wall during high swells. While property is protected, the beach between the property and the sea is more quickly reduced and public recreational area is diminished (U.S. Army, August, 1971).

Any structure protruding into the ocean can act as a groin. Landfills built to support highways swinging out into the ocean can have downcurrent groin-like effects.

Localized erosion problems can also ensue from the removal and/or alteration of sand dunes by making the beach more susceptible to erosion. Dunes protect the land behind the beach from erosion and flooding and serve to hold and extend the beach itself (Oxnard Planning Dept., September, 1972). Merely the pedestrian use of dunes can weaken surface vegetation and destabilize them to a point where they become less able to contain storm waves.

For Southern California in general, it has been stated that the coastline is presently in a state of retrogradation, as evidenced by its straight alluvial coasts and the absence of beaches along rocky coasts, indicating a general dominance of wave activity over stream deposition of sediments (So. Calif. Assoc. of Govts., February, 1972). This may be supported by the fact that 87% of the coastline of Southern California is erosional, as opposed to depositional (So. Calif. Water Research Project, March, 1973). It has also been stated that "There is evidence that the artificial drainage systems developed in Southern California coastal watershed have created a general condition of retrogradation. This may be one of the greatest impacts that man has made upon the natural environment to date." (So. Calif. Assoc. of Govts., February, 1972). The same source states further that, "The fact that the sands will eventually be depleted from our shores in significant amounts is especially disturbing because it might occur catastrophically rather than gradually. On an annual basis stream energy distributions are erratic while wave energy distributions are relatively constant. We know, for example, that most of the 7 million cubic yards of sand transported to the shore by the Santa Clara River during 1933-1938 was delivered in a flood during a 4-day period of February - March, 1938. This volume represents about a 7 - 10 year supply for the waves along the Ventura-Oxnard coast where water-impounding dams and flood control now greatly restricts the input of sediments into the ocean."

On the West Coast, where rivers and streams are by far the major source of sea sediment, flood control measures to protect development in flood plains and water supply dams are estimated to trap 50% of the sediment that once replenished the beaches (Soucie, June, 1973). Over 50% of Southern California's watershed is behind dams (36.5% for Ventura County). The National Academy of Sciences - Committee on Oceanography recently noted that runoff control in Southern California has severely cut the supply of sand, and without some intervention, the beaches may seriously deteriorate within the next two decades (Orange County Planning Dept., November, 1971).

It should be kept in mind that sand supplies in Ventura County have not been cut off as much as it has in Southern California as a whole, and may have unique circumstances involved in terms of topography, etc. This makes it all the more urgent to examine what might be the potential outcome of the trends which have been set in motion .

While the immediate results of flood control improvements include both increased safety for those living along the inland flood plains as well as the creation of more developable land, the flood control facilities often channel to the ocean water containing far fewer sandy particles than are necessary to even hold the line on threatened beaches (Orange County Planning Dept., November, 1971). Channeling of stream beds and dam construction for soil erosion prevention or flood control have reduced beach sand supply and changed prograding river deltas into tidal inlets, consequently including beach erosion (So. Calif. Assoc. of Govts., February, 1972). When river deltas and adjacent feeder beach areas are reducing by withholding sand supplies, in the face of persistent longshore currents, the result is a gradual recession along all of the shoreline that is dependent on the tributary drainage area as a source of replenishment (U.S. Army, May, 1972).

Such effects in adjacent counties have been documented via analysis of Southern California watersheds. Little beach building material is derived from the Malibu Creek watershed except during large storm runoff because of five reservoirs on Malibu Creek watershed built between 1881 and 1925. The accumulation of debris by these reservoir developments has reduced the passage of potential littoral materials to the coastline (U.S. Army, August, 1972). The Santa Maria River in Santa Barbara County has more than 75% of its sediment cut off by the Twitchell Dam (Calif. Dept. Water Res., July, 1969).

For Ventura County, in 1961 the Army Corps of Engineers asserted that prior to 1948 there were no restricting structures on any of the streams making up the Santa Clara and Ventura River basins. However, since 1948 the total drainage areas of the streams have been reduced by about 1/3 by the construction of the Matilija, Casitas and Santa Felicia Reservoirs (U.S. Army, April, 1961). In 1962, the Army Corps further asserted that construction of these reservoirs and the relatively dry years after 1948 were estimated to have decreased sand supplies by at least 1/2. This reduction in material supply, part of which is permanent, had caused substantial recession of the shoreline (U.S. Congress, May, 1962). The erosion between the Ventura and Santa Clara Rivers was expected to continue, in view of the prevailing dry years and the resultant lack of flood

runoff from the streams which had previously supplied littoral material to the area. It was estimated that due to the construction of reservoirs on Matilija and Coyote Creeks since 1948, sediment contribution to the ocean from the Ventura River has been reduced by 50% (U.S. Army, April, 1961). Another study of the Ventura and Santa Clara Rivers showed that prior to 1948 these rivers contributed approximately 1,702,000 cubic yards of sediment annually to the littoral zone. By 1963, controls and a series of dry years had reduced the quantity of sediments to the coast to an average of about 716,000 cubic yards per year. Sediment contributions from these streams was expected to be further decreased in the future (Watts, 1963).

Still another study calculated that dams in the Santa Clara and Ventura Rivers reduced in those rivers the annual average production of sediment, considering only those grain sizes suitable for beach nourishment, from 1,230,000 to 700,000 cubic yards. The calculations incorporated 50 year averages of rainfall, so that the effects of the dams were isolated from that of fluctuating rainfall in the short term (Calif. Dept. of Water Res., July, 1969).

It should be noted that the 1969 floods of January and February, because of the unusually heavy rains of that period, deposited about 13 million cubic yards of sediment at the mouth of the Santa Clara River. This could have a significant effect on some of the earlier estimates of annual sand supply, if taken into account.

Dams for water retention have the ability to contribute to beach erosion in several ways. Because they trap practically all of the sediment in the stream, they reduce the watershed area capable of supplying sand to the beach (See Illustration 6.2). The watershed area which they block off is usually in the upper reaches of the tributaries, where stream velocity and rainfall is greatest and most of the sediment is generated. For example, it has been observed that the Ventura River currently carries only a small fraction of the former volume of sediment because of the construction of the Matiliga Dam, and the Matiliga Dam controls only 24.3 percent of the drainage basin (Norris, 1964). They also lower peak flood velocities by controlling the amount of water released, which reduces the ability of streams to carry sediments, especially the larger particles. The large grained sediments are important to the beach because they are not easily erodible and help to hold the beach together (Drelicharz, 1974). They also "bounce" along stream bottoms during floods and create additional sediments (Norris, 1964).

The "clean" water which flows downstream from dams has the capacity to pick up sand up to its carrying capacity if sand is available and the slope is steep. However, by doing so the water erodes downward, which can reduce the gradient of some portions of the stream and thereby decrease stream velocity, which in turn diminishes the ability of the water to carry sediments over the long run (Drelicharz, July, 1974). Also, at some point in time, stream flow will winnow from the channel bedload below controlled portions of the watershed the smaller sand grains which are easily transportable, after which the amount of sand transported will be sharply decreased, and shores will deplete rapidly and waves will attack the shores directly (So. Calif. Assoc. of Govts., February, 1972). This point in time may be far off into the future in Ventura County watersheds because of the sharp gradient and the abundance of sand in the stream channels below dams. However, no one can predict when it might occur, without a program of continual monitoring and measuring of sand supply movements.

The existence of dams in Ventura and Santa Clara River waters was singled out by the Army Corps in 1961 as an important determinant of current and continuing beach erosion in Ventura County and was used as one of the justifications for the groins at Pierpont. The recent construction of the Castaic Dam has cut off more of the sediment-generating watershed in the Santa Clara. The construction of more water-impounding dams could further the impact. For instance, the Department of Water Resources had predicted that sediment production in the Santa Clara Watershed would be further decreased from an average of 600,000 cubic yards annually to 250,000 cubic yards annually with the future construction of dams on Castaic Creek (completed) and on Topa Topa and Cold Springs (since abandoned) (Calif. Dept. of Water Res., July, 1964).

The Army Corps of Engineers, in their Environmental Impact Statement for the Ventura Marina, stated that "Future reductions in the rate of supply of sand from river sources to the beaches downcoast from Ventura Marina, occasioned by the construction of upstream reservoirs, may cause long-term erosion in this area unless measures (such as groin construction) are taken to protect the beaches from erosion" (U.S. Army, Sept., 1970).

Flood control projects such as debris basins also catch sand and prevent its movement down to the beaches. For example, after the 1969 floods, 12 of the 26 debris basins in the county were cleared or about 400,000 cubic yards of sediment (Ventura County Department of Public Works, June, 1972). (The 1969 floods, estimated as a 1%

frequency of occurrence for the Santa Clara River and 2% for the Ventura River, deposited more than 13 million cubic yards of sediment at the mouth of the Santa Clara, an enormous amount despite the retention by dams and flood control projects, because of the unusually heavy rains.) Debris basins tend to settle out the larger particles of sand which are more important to the beach. Unless the basins are very large they have relatively little effect on peak flood flows. The facilities are designed to trap debris and sediment and pass flood flow over the spillway as cleaner water which picks up material from the downstream channel. The possible long term effect of releasing this "clean" water has already been mentioned.

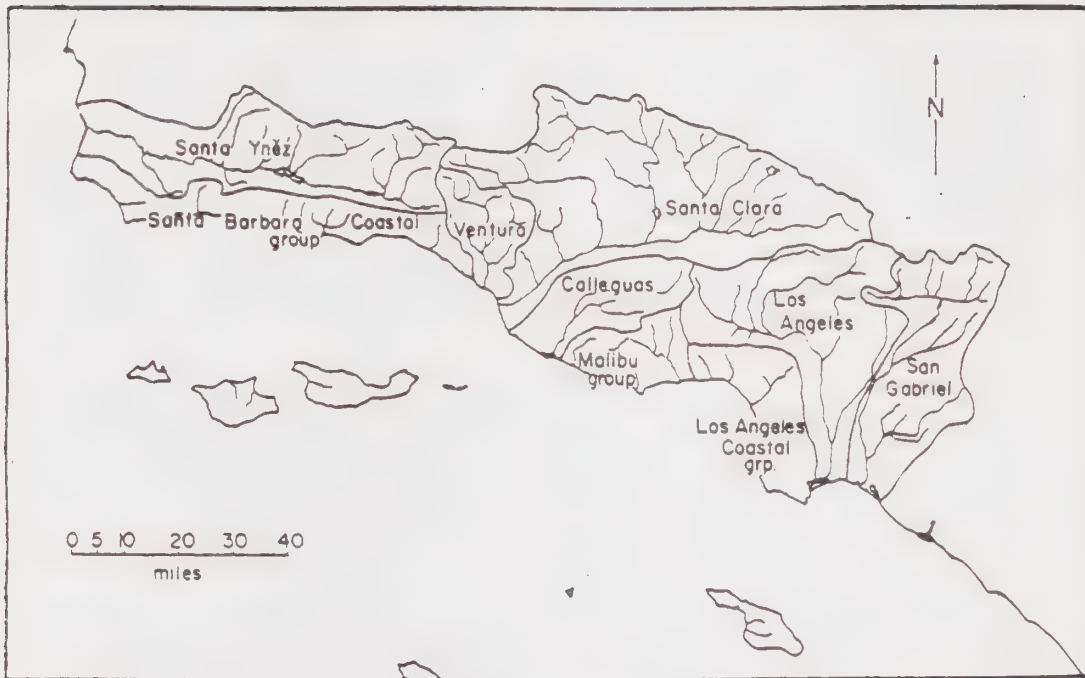
One should be reminded that there are large public benefits associated with dam and flood control operations, such as the protection of life and property, water conservation, recreation and the opening of land to development and agriculture. It is probable that some of these benefits are of greater public importance than the preservation of our beaches. However, property loss can also ensue from beach erosion, and the beaches themselves constitute a resource of great economic and aesthetic value. Difficult either/or decisions are not always necessary, because remedial measures often can be incorporated into stream development structures. At least a modification of present thinking by including regular consideration of beach sand supply in all new stream development programs could be taken.

As stream development proceeds and the amount of sand which floods would normally carry to the beaches is critically reduced, we may expect in Southern California a slow but continuous shrinkage of our beaches, and we may have about 20 to 40 years to institute remedial measures (Norris, 1964).

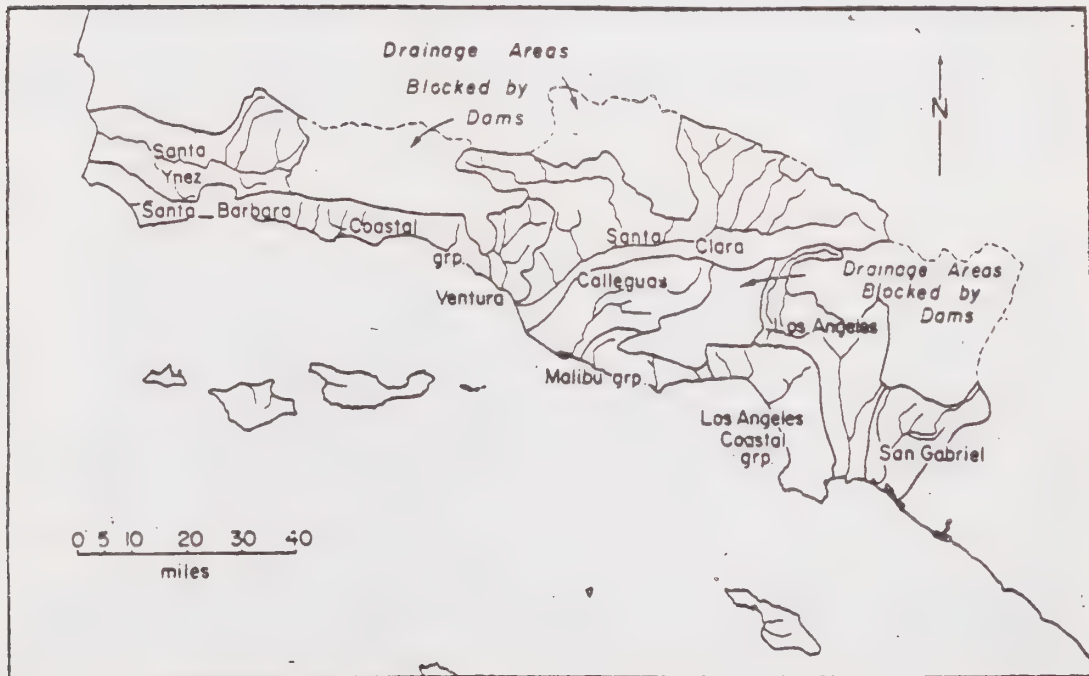
In addition to flood control projects and damming operations which provide sources of water and flood protection, river bottom gravel operations which "mine" river sediments for use in constructions can remove beach-destined sand supplies to a significant degree. For instance, one such operation, the Southern Pacific Milling Co. on the Ventura River, alone removes more than 5% of the remaining sands moving downcoast of the Santa Clara River (based on annual average), and more than 14% of the sand flowing between the Ventura and Santa Clara Rivers (Ventura County Planning Dept., July, 1974). As well as extracting sand which might have replenished beaches, mining operations create open pits which act as sand traps and prevent the trapped sand from moving further downcoast (Calif. Coastal Zone Comm., April, 1974).

Although development contributes an initial surge of sediments to streams, as urbanization encroaching

Illustration 6.2



Generalized coastal drainage basins in the northwestern half of southern California



*Dams and Beach-Sand Supply in Southern California
Undammed or unobstructed portions of coastal drainage basins
in the northwestern half of southern California
(As of 1964, does not include Castaic Dam)*

upon flood plains becomes established, erosion is reduced because of the storm drains which immediately catch water and the grasses, paving and buildings which replace exposed soil. Bernard W. Piphen, a USC geologist, has stated in a general sense that: "What few studies have been conducted suggest that sediment delivered to the beaches will be decreased by 30% by the year 2000, even if no more dams are constructed (Soucie, June, 1973).

Urbanization of areas adjacent to the stream sources of beach replenishing sediments can therefore be a major factor in beach erosion, apart from the flood control and water supply construction it demands. In Orange County, rapid urbanization and channelization of watersheds for flood protection has necessitated the construction of groins and sand dredging and pumping in Seal Beach, Sunset-Surfside Beaches, Newport Beach and Doheny Beach at a cost in excess of \$7 million over the last 5 years (Orange County Planning Dept., November, 1971). The significant reduction in sediment material derived from the Santa Ana, Los Angeles and San Gabriel tributary drainage areas caused by the intense encroachment of Southern California urbanization and other land use developments has necessitated artificial fill programs at Surfside-Sunset Beach. Without these beach fill programs, the shoreline at Surfside-Sunset would be under continuous recession (U.S. Army, May, 1972).

Since the floodplains of Ventura County are still relatively undeveloped these effects of urbanization on beach sand supplies in Ventura County are far from their potential. However, in light of this fact it must alternatively be recognized that most of the sediment producing watershed in Ventura County is located in mountainous terrain unsuitable for urbanization.

It has been estimated that the Santa Paula Creek flood control project might reduce sand in the littoral drift circulation by less than 2%. Its effects might be diminished by the fact that given the tremendous amount of sand in the Santa Clara River and its steep inclination, the amount of water flowing in the river is really what determines the amount of sand carried to the beach (Ventura County Beach Erosion Study, July 1973). However, one must assess the cumulative effects of many such projects, as well as damming operations which withhold water and the total effects of urbanization, in order to predict the irreversible impacts of inland development on beach sand supplies over a long period of time.

It may be said then, that long-term, continuing, general states of net beach erosion (which subsume short-term cycles) can have natural or man-induced origins.

We are probably in a general state of erosion at present in Ventura County, and human activities likely are a major contributing factor. The man-made impacts on beach sand supplies are for all practical purposes irreversible, and in the absence of remedial measures could continue at an increasing rate into the foreseeable future as the county becomes more urbanized in the flood plains, and particularly if more water impounding dams are built. The current extent of these human impacts in Ventura County can only be determined by new studies which are based on updated information reflecting more recent conditions, such as the construction of the Castaic Dam and the advent of the 1969 floods.

DETECTION

It is evident that beach erosion is a dynamic, ongoing process. It can have short-term, dramatic effects as well as long-term, more subtle effects. It can go through cycles of varying lengths of time, and can be part of a general trend over a very long period of time.

How you detect beach erosion, then, depends on exactly which aspects of it you wish to see. Shoreline recession from intense storms at sea can be estimated by the casual on-site observer, as long as he has a good idea of how far the beach extended before the storm. The elucidation of long-term changes or trends, including erosion cycles, require more continuous observation. Old aerial photographs, Army Corps studies, and even mission records can help trace historical changes to see what has happened in the past and what is likely to happen in the future, by establishing a zone of shoreline fluctuations. This type of data usually isn't complete enough to trace exactly what trends have been dominant through time. However, it can help determine what areas have been most susceptible to erosion at various points in time, relative to the whole coast, and how much the width of these areas is capable of fluctuating.

Erosion susceptibility can also be estimated through the use of wave refraction studies, in conjunction with analysis of beach slope and grain size. A combined effort such as this would establish the relative magnitude of wave energy reaching various portions of the beach, and the resistance of these areas to the force of waves. Computer models simulating stream sediment transport and the littoral drift can help predict the effects of inland sand retention on the sand budgets of littoral cells, and the complete downcoast effects of protruding oceanic structures on the littoral flow.

Shoreline changes can be monitored exactly through a continuous program of aerial photography and measurement of onshore elevations and offshore depth contours. Small changes in the present could then be detected, and a baseline of data for uncovering long-term trends would be supplied for future reference.

GENERAL EFFECTS OF THE HAZARD

PRIMARY EFFECTS

People have shown a natural affinity for the coastline. They locate their structures in close proximity to the ocean for purposes of easy accessibility to and close association with the marine environment, often removing natural protective barriers in the process. They are unlikely to be appreciative of the hazards to life and property involved with their decision to build on changing, impermanent land, if they haven't observed the beach over a long period of time. Man, in his eagerness to be close to the water, loses sight of the fact that land comes and goes, and that land which nature provides in a given period may later be reclaimed by the sea (U.S. Army, May, 1964). The end result is the direct destruction of homes and property as foundations are undermined by the advancing sea and the structures themselves are attacked by waves whose force is no longer dissipated by wide beaches.

The millions of dollars of damage caused by coastal erosion is borne not only by private individuals. The public sector suffers damages to streets and utilities which are supportive of beach development subject to erosion hazards.

SECONDARY EFFECTS

Since erosion reduces the protective capability of the beach against waves, it can increase the flooding hazard of areas of low land profile during storm activity. This is especially true where other protective barriers such as dunes have been removed. Flooding can imperil life as well as inflict property damage.

In certain cases, erosion can unearth septic tanks and cause effluent to run onto the beach and flush directly into the ocean, creating a public health hazard and a threat to marine biota as well.

Beach erosion can reduce the amount of recreational beach available to the public, particularly when sea walls are used to impede it. However, this is a lasting

effect only under conditions of general, long-term erosion, since the amount of beach available for recreation has always fluctuated. During periods of acute erosion, the land itself can be eroded away, permanently losing its soil to the ocean.

The cost to taxpayers is another secondary effect. The public must pay for street and utility damage, and funds rescue and clean-up operations. Low interest disaster loans continue the relief effort. Public agencies are afterwards called upon to spend large sums on erosion protection measures to avert further disaster and protect large investments which have encroached upon the beaches. In some cases, governing bodies are sued by homeowners for allowing development to have commenced in the first place in areas subject to erosion hazard.

DURATION AND EXTENT

The duration of hazard from beach erosion depends on a host of meteorologic and geologic factors. Most of the immediate hazard comes from storms, which can last several days or more, and cause severe erosion, flooding, and structural damage. However, a net erosion factor can prevail over several months or even many years, which in turn leaves the shoreline more susceptible to erosion and flooding and structures more vulnerable to wave damage. Continuing, long-term erosion can stem directly and indirectly from the urbanization of watersheds. The effects of urbanization on sand supplies is for all practical purposes irreversible, and in absence of remedial action could continue at an accelerating rate into the foreseeable future as flood plains become more urbanized.

The extent of hazard can be confined to several hundred feet inland from the mean high tide line, except for coastal flooding that is made possible by extensive erosion, which may spread over a considerable area in the coastal zone once the waves overtop physical barriers.

GENERAL INVENTORY OF THE HAZARD

LOCATION OF THE HAZARD

All beaches in Ventura County are subject to erosion to a certain degree. Even beaches stabilized by groins can erode, only at a slower pace. Erosion will accelerate in the future at all beaches if sand supplies to the coast are further decreased.

Areas which have in the last few years undergone

severe beach erosion are shown in Plate IV. This was taken from an inventory of beach erosion damage in Ventura County completed by the Department of Public Works in 1972.

HISTORY OF THE HAZARD

The history of beach erosion in Ventura County is sketchy, due to a lack of documentation. Unfortunately, there has been no ongoing shoreline monitoring program in the past, and the information has been evolved piecemeal. Some of what is available indicates that the shoreline does indeed come and go, and property has been damaged by beach erosion in Ventura County.

Records indicate, for instance, that the area between the Santa Clara River and Port Hueneme, which includes the Oxnard Shores area, advanced roughly 500 feet from 1856 to 1938 (U.S. Army, April, 1961), and more from 1938 to 1959. Consistent advance of this shoreline indicated that available sand supply had exceeded the transport capacity of littoral forces (U.S. Army, October, 1948). This trend towards shoreline advancement was reversed in 1959 at Oxnard Shores. The area was at its most seaward position from about 1955 to 1959, due to the 1938 and 1943 floods. From 1959 to 1972, the shoreline moved landward about 140 feet, and should continue to move landward at this rate (11 ft./yr.) for the next three years, until that time when the 1969 flood sands are expected to reach the area in large quantities (Moffat & Nichols, August, 1972). Subdivision activity began in 1959, and since then homes have been destroyed and utilities endangered (Oxnard Planning Dept., 1972). In February of 1973, Governor Reagan declared Oxnard Shores a flooding disaster area. Apparently, storms have caused millions of dollars worth of damage here.

Pierpont Beach similarly advanced 1,000 feet from 1856 to 1948 (Ventura Port District, August, 1953), reversing this trend by eroding 300 feet from 1948 to 1961, until stabilized by a series of seven groins constructed between the Ventura Pier and the Ventura Marina shortly thereafter. The entire area between the Ventura and Santa Clara Rivers lost approximately six million cubic yards of sand from 1938 to 1959 (U.S. Army, April, 1961). Still, this amount of recession didn't bring the beach back to the limit of the extremely narrow 1855 shoreline, and wouldn't have up to now even without the stabilizing groins (it was predicted in 1961 that Pierpont would reach the 1855 line at the then current rate of erosion by 1986). Construction was discouraged by erosion damage caused by storms in 1936 and 1938 (over \$1,000,000 of damage was incurred at Pierpont in 1938), but the area has grown rapidly since 1950, giving rise to many homes which would have been under water in 1855 (See Illustration

6.3) (U.S. Army, April, 1961).

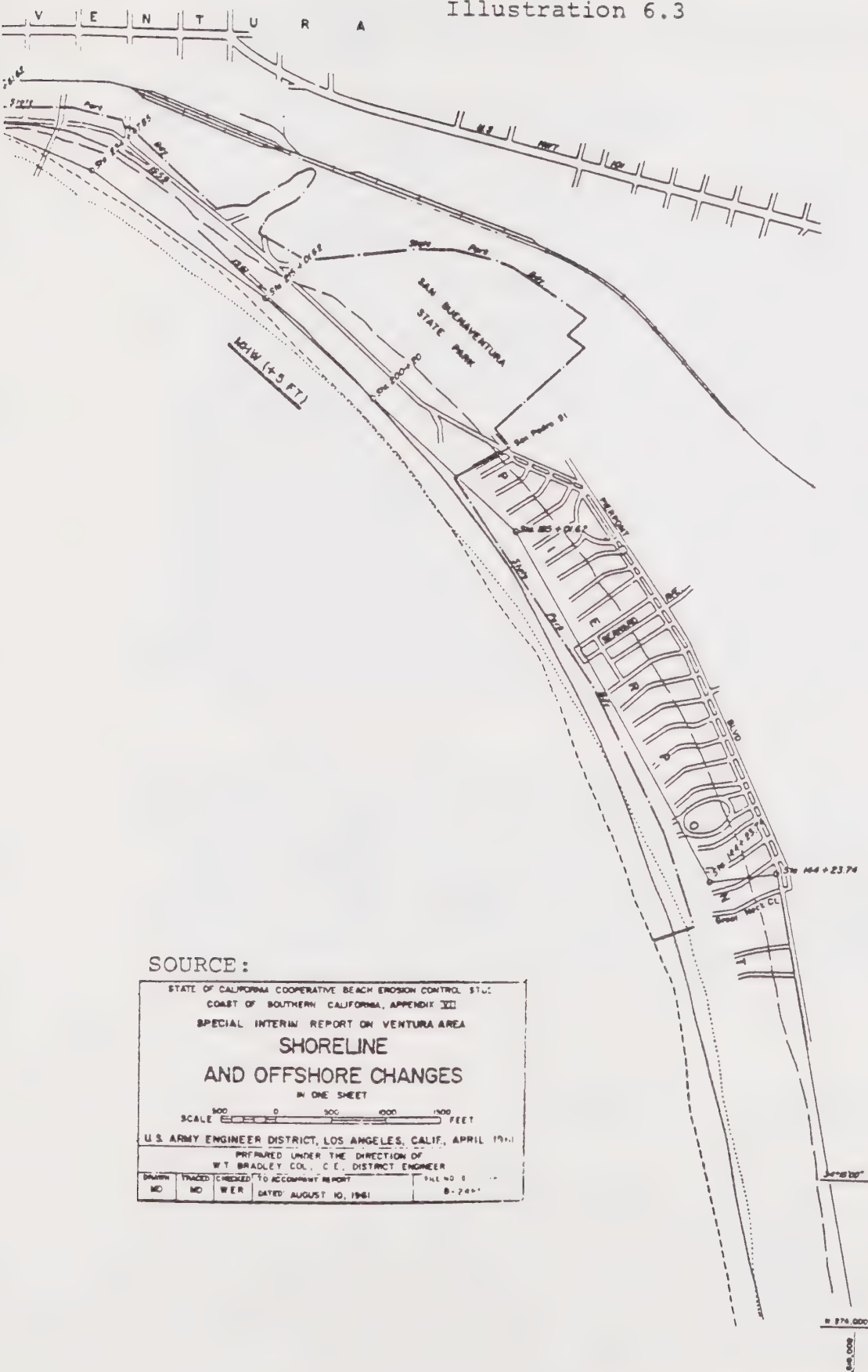
The lack of data before 1855 and between 1855 and 1938 on shoreline changes (a partial survey was made in 1869; other data may yet lie uncovered), leaves questions about the validity of these apparent trends. 1855 conditions may have resulted from a period of acute erosion following severe storm activity and may not be indicative of this time period. Whether or not the trends at Pierpont over the last century are indicative of the whole Ventura County coastline is questionable. More than a century ago the Santa Clara River migrated northward, causing convexity at its mouth, and acted as a groin, which may explain why Pierpont advanced steadily from 1855 (Ventura Port District, August, 1953). The width of the shoreline there is, therefore, very dependent upon the size of the adjacent Santa Clara River delta. In light of these facts, it is interesting to postulate that the Santa Clara is due for a shift to the south due to the continuing subsidence of consolidating sediments on the Oxnard Plain, but this is not likely to happen due to the construction of levees.

The historical occurrence of erosion induced by man-made structures has been documented as well. Subsequent to the construction of jetties at the entrance to Port Hueneme in 1938, the shoreline directly upcoast advanced 600 feet by 1948. During the same period the shoreline four to five miles upcoast receded 400 feet (Ventura Port District, August, 1953), and the shoreline directly downcoast from a seawall built adjacent to the east jetty receded 700 feet, the recession tapering to zero six miles downcoast. Prior to this construction, the beaches from Port Hueneme to Point Mugu receded and advanced an average of about 200 feet, with no apparent trend since 1855 (U.S. Army, October, 1948).

DEFINITION OF HAZARD ZONE

The beach erosion hazard zone will be defined as areas along the Ventura County coast which encompass beaches extending parallel to the shoreline along the areas designated in this report as being subject to severe beach erosion, and which extend from the mean high tide line of these beaches (Summer, 1974) 500 feet inland or to a distance where a rise of 15 feet in sustained elevation over the mean high tide line is first reached, whichever comes first. The 15 foot figure was chosen because it represents the verticle elevation susceptible to wave damage from maximum storm surge in combination with maximum wave height (8 feet and 7 feet). The 500 foot figure was chosen because while some broad, low-lying beaches may be protected from immediate wave damage several hundred feet inland, they nevertheless may erode many feet over a long period of time. Since Oxnard

Illustration 6.3



SOURCE:

STATE OF CALIFORNIA COOPERATIVE BEACH EROSION CONTROL STUDY			
COAST OF SOUTHERN CALIFORNIA, APPENDIX III			
SPECIAL INTERIM REPORT ON VENTURA AREA			
SHORELINE			
AND OFFSHORE CHANGES			
IN ONE SHEET			
SCALE 0 500 1000 1500 FEET			
U.S. ARMY ENGINEER DISTRICT, LOS ANGELES, CALIF., APRIL 1961			
PREPARED UNDER THE DIRECTION OF			
W. T. BRADLEY COL., C.E., DISTRICT ENGINEER			
DRAWN	TRACED	CHECKED	TO ACCOMPANY REPORT
MD	MD	WER	DATED AUGUST 10, 1961
			FILE NO. 8
			B-2401

LEGEND

- 1855 - - - - -
- 1948 - - - - -
- 1959, 1961 - - - - -
- C of E L.A. Dist
- U.S.C.E.C.

Shoreline Changes at Pierpont from 1855 - 1936

Shores is approximately 500 feet seaward from where it was in 1856, this indicates the erosion potential for this type of broad, low-lying beach in Ventura County.

Sites within the hazard zone might be suitable for certain structures if protected by a sizable barrier such as several rows of previously existing houses, or an extensive dune line. These sites would probably still be susceptible to flooding, however. A location set back well on a shelf of land of resistant rock under 15 feet of elevation and fronted by a very narrow sandy beach would also probably be suitable for development.

It is obvious that the erosion hazard increases along any shoreline with proximity to the ocean. It also must be kept in mind that all portions of sandy beaches are subject to erosion and can be classified in at least a low hazard zone. The beaches are created by the sea, and it has the ability to undo what it has done. Even groins which "stabilize" a beach serve only as a delaying mechanism against erosion caused by relentless processes (Orme, July, 1974). The 500 foot horizontal delineation should be regarded as conservative in the long run, in the face of a lack of knowledge which documents the full range of historical shoreline fluctuations, the continual alteration of shoreline configuration by man-made structures in the ocean, and the ever increasing adverse effect of human activities on beach sand supplies.

NATURE OF INFORMATION

The lack of information on historical erosion trends and current erosion susceptibility prohibits the detailed determination of local beach erosion hazard. A more fine-grained analysis would be enabled by filling in gaps in the historical data, from such possible sources as Army Corps records, mission records, and old aerial photographs. The location of areas currently undergoing severe beach erosion, as determined by Public Works in 1972, will have to be updated as erosion patterns change in response to changing natural and human influences on the shoreline.

GENERAL MANAGEMENT RESPONSIBILITY

The Army Corps of Engineers is currently conducting a study on the Ventura County littoral drift and related problems. Their report is due by 1978, and will inventory current erosion problems and recommend solutions. For planning purposes, it hopefully will also provide a certain amount of predictive capability for estimating future shoreline conditions, by projecting natural and man-made processes which effect beach changes.

Major flood control and erosion correcting measures are almost always undertaken by the Army Corps of Engineers. As a prerequisite, the County must first request assistance from the Corps, after which the Corps then seeks approval from Congress for federal funding, which covers construction costs on the order of 50% for beach erosion projects, and up to 100% for flood control projects of regional significance. Local and state agencies pay for right-of-way and utility relocations. The County Public Works Agency lends coordinative and technical assistance to the Corps for major projects, and also undertakes flood control projects of a lesser significance. It is now Board Policy that the County Parks and Recreation Department manage the use of beach erosion corrective measures for County property. The Public Works Agency will lend technical and coordinative assistance to this end. The State has also been known to construct erosion impeding structures, such as the rip rap wall at Seacliff.

Local government agencies charged with land use regulation are responsible for managing the placement of structures and facilities in undeveloped areas subject to beach erosion. Their actions ultimately determine whether or not there is going to be an erosion problem, whether or not measures will be necessary to protect endangered property from erosion. Additional incompatible land uses can be kept out of erosion hazard zones through the various land use regulatory devices at the disposal of local governments, supplemented by the environmental impact review process.

The Flood Control Department of the County Public Works Agency also has limited responsibility for flood plain management in the County. The cities do as well, when flood plains comes under their jurisdiction. By regulating urbanization in the flood plains, there could be less of a need to protect development from floods through flood control structures, and the effects of urbanization on sediment production in the flood plain could be lessened.

LOCAL DISCUSSION

LOCAL INVENTORY OF THE HAZARD

Intermittent portions of the beach are included in the beach erosion hazard zone for both the North and the South coasts. For the County beaches, none of the hazard zone extend inland the full 500 feet. The hazard zone is generally located at Rincon Point, Punta Gorda, Seacliff Colony and Hobson Park, Pitas Point and Faria Colony, Solimar Beach, Bass Rock, and Solromar. The State beach and naval reservation at Point Mugu are also within the hazard zone.

LOCAL RESOURCES AFFECTED BY THE HAZARD

Numerous residences are located in the hazard zone and are likely in danger of being destroyed or damaged as a result of being undermined by erosion or from wave and flooding damage stemming from erosion. Most of these residences are located in the communities of Rincon, Mussel Shoals (Punta Gorda), Seacliff, Faria, Solimar, and Solromar. A hotel and restaurant in Punta Gorda are also within the zone.

Continued erosion would decrease the amount of a available recreation beach in this area over time, which is already very small. The building of seawalls to protect property increases this effect.

Three parks, Hobson County Park, Faria County Park, and Point Mugu State Park, also lie within the zone. Public investment in the parks are subject erosion damage.

FINDINGS

PROBABILITY OF OCCURRENCE

Beach erosion occurs over varying time spans with varying rates of incidence. Some erosion is correlated with changes in the weather and other natural phenomena. There can be short-term, rapid erosion from storms, seasonal and tidal fluctuations, and cycles which cover 25 years or so and are correlated with sunspot activity. Short-term erosion can also be man-induced, as from groins and jetties. There are also long-term, continuing trends of erosion which can have natural and/or human origins. Shoreline fluctuations which occur over the shorter time periods are much easier to predict than the longer trends because they occur more often and more is known about them. However, a continuing, long-term, general state of erosion at County beaches may become dominant in the future if the increasing urbanization of the County subtracts further from the amount of debris-producing areas in the flood plains of the County, and leads to additional stream development and, most importantly, water-impounding dams. This would be particularly true if the human impacts on beach sand supplies are not offset in the future by the occurrence of major flood flows, such as the 1969 floods.

SEVERITY OF THE HAZARD

Beach erosion occurs with varying degrees of severity. Tidal fluctuations cause little change in beach profile, while major storms, particularly when at high tide, can cause the coast to rapidly recede. Long-term trends may be undiscernible to the casual observer, but may have catastrophic effects when they result in the erosion of many feet of beach over a long period of time. Erosion severity can change from place to place along the coast at any one point in time, in response to changing wave patterns and geomorphological features.

Based upon past history of other areas of Southern California, it can be said that as the urbanization of the County increases in the future, the general severity of incidences of beach erosion will also increase. However, remedial measures taken by the proper management of water resources and sand supply, and the occurrence of major flood flows, could reduce the hazard.

RESOURCES AFFECTED

In the unincorporated areas, residential structures and supportive facilities comprise the major resource

affected by beach erosion. Erosion can undermine structural foundations on the beach, and allow waves to batter the structures themselves. Good soils from the land itself can be permanently eroded away if all of the sandy beach with its protective capability is removed. Seawall installation to protect structures have the effect of decreasing recreational beach seaward of the wall. Normally, natural features such as beaches and sand dunes affected by beach erosion are usually restored by natural processes over time. The total amount of recreational beach available over time can be reduced by those human activities which induce general, continuing states of beach erosion.

NATURE OF INFORMATION

The information used in this report, namely current inventories, research papers, and historical studies, was adequate to establish a general erosion hazard zone and predict a possible worsening of future conditions. More detailed information is needed to establish more fine-grained hazard zones sensitive to local conditions, and anticipate future erosion with more accuracy. Hopefully, the Army Corps study due in 1978 will be informative in this way.

OTHER FINDINGS

Most of the resources affected by beach erosion in the unincorporated areas lie north of the Ventura River, where sandy supply originates primarily from small streams upcoast in Santa Barbara County. The area is for the most part mountainous and undergoing uplift (and, therefore, wave erosion of bare rock). There are three major headlands in the region: Rincon Point, Punta Gorda, and Pitas Point. They have an asymmetric shape because of the prevailing direction of wave approach, and for the same reason are experiencing active erosion on their eastern side. The relative lack of sand supplies traveling along the northern coast of the County compounds this effect.

Beaches from Rincon Point to the Ventura River are very narrow and are usually covered at high tide. U.S. Highway 101 and the Southern Pacific Railroad closely border this beach, and for 3/4 of this distance are protected by revetment seawalls and bulkheads. Historical photographs taken from 1959 to 1969 showed little shoreline change at Seacliff, Punta Gorda, Solimar, and Emma Wood. Hobson and Hoffman parks were wider in the winter than in the summer (U.S. Army, December, 1970). This summer these beaches are narrow in comparison to previous summers, and serious erosion could take place with increased storm activity in the approaching winter

and property may be threatened.

Large scale structural measures to impede erosion and protect property, if determined feasible, cannot be undertaken until after the Army Corps completes their 1978 study. Special interim measures are being taken by the Corps to protect Hobson and Faria parks. In any event, they will only protect shoreline of "regional significance". The property owners' only practical recourse to protect their property is through the use of seawalls, especially of the rip rap type. The eventual outcome will be a fortified "line of defense" against the waves, with little recreational beach even at low tide. Care should be taken to see that the seawalls are firmly anchored, and do not produce substantial erosion at other locations where resources are affected (or they too will have to be fortified).

The southern portion of Ventura County coastline, between Point Mugu and the Los Angeles County line, also has very narrow sandy beaches backed by mountains (the beaches directly upcoast of Point Mugu have historically been wider and more stable because Point Mugu acts as a groin by catching sand). Historical photographs over 10 years indicate that Sycamore Beach and the narrow beaches penetrated by 10 groins between Bass Rock and Little Sycamore Creek have shown little change. The public beach at the mouth of Big Sycamore Canyon, however, is extremely variable, and is usually widest in November (U.S. Army, December, 1970).

OPTIONS

1. Carefully examine any proposals for direct alteration of shoreline configuration, or structures which protrude into the ocean, including groins, jetties, and breakwaters, to insure that the detrimental effects to natural processes, which includes increased erosion of downcurrent beaches, are avoided. This should be completed before substantial financial commitments are made.
2. Utilize structures which impede beach erosion and/or wave activity, such as groins, jetties, and seawalls only where property is clearly in danger of being destroyed or eliminated, or where overriding public benefit clearly demonstrates the need for additional marine installations. These structures should be designed in such a way as to minimize erosion seaward of the structures and at adjacent points along the shore.
3. In the design of necessary flood control/water retention structures such as dams and debris basins, give full consideration to the potential effects of the retention of sand which would normally flow to and replenish the beach, and alternatives to reduce and/or mitigate adverse impacts. Give attention to the cumulative impacts of individual projects by looking at the impact of all planned or proposed projects, instead of looking at projects on a case-by-case basis only. This should be done before substantial financial commitments are made.
4. Emphasize flood plain management as an alternative to structural measures by regulating urbanization of flood plains.
5. Evaluate riverbed mining operations as to their effects upon sediment transport. Excess material dredged by the operations should be made available for stream transport, if feasible.
6. Give utmost concern to the preservation of existing sand dunes, except if blown too far inland to serve as protective barriers against erosion and tidal flooding. Stabilize existing dunes via surface vegetation and construct artificial dunes where appropriate.
7. Keep land uses which are subject to serious property damage from beach erosion out of beach erosion hazard zones. Control the siting and design of uses in erosion hazard zones to minimize the danger of property damage from erosion, such as requiring deep

pilings for houses.

8. Establish regulations for enforcement of beach erosion policies. These would include: (1) Building Codes can specify construction standards such as building elevation, seawall construction, and flood proofing which can reduce losses from flooding and erosion; (2) Zoning Regulations can define minimum protection elevations for buildings, and setbacks from shoreline in low hazard flood or erosion areas, and strigently restrict uses in high hazard areas; (3) Subdivision Regulations can condition subdivision in hazard areas to overcome hazard through structural measures such as seawalls and other erosion control structures or techniques; (4) Miscellaneous Regulations such as ordinances which protect dunes, regulate sand mining, control the construction of seawalls, groins, jetties, and flood control measures, and define structural setback requirements.
9. In the absence of regulations controlling land use specifically in the beach erosion hazard zone, afford owners of hazard zone property all available information which serves to warn them of the threat of hazard within the zone.
10. Generate information which would enable the determination of more specific hazard zones sensitive to local conditions, possibly dividing the hazard zone into high hazard and low hazard zones. Historical information as well as geologic and hydrologic data dealing with such aspects as wave refraction, grain sorting and shore slope would be needed. Local agencies can work with the Army Corps of Engineers in this regard, to see that their 1978 shoreline study contains information useful for planning purposes, instead of merely substantiating the need for structural solutions to current problems. Some site specific information of this type can be requested from development applicants by local agencies as a requirement of environmental impact reports for development within the hazard zone.
11. Model the dynamics of sand transport in County watersheds and the littoral drift along the coast to establish predictive capability for determining the effects of upstream water management projects and protruding oceanic structures on the sand budget of the littoral cell.
12. Monitor shoreline fluctuations on a continuing basis using aerial photography and on-site measurement in order to estimate current erosion

in process, as well as establishing a baseline of data for future studies.

13. Initiate a comprehensive beach management program at the County level, which would deal with all aspects of beach erosion, including flood plain management and the sources of sand, and would conduct relevant studies and carry out established policy regarding sand management. The program would coordinate its efforts with and have input from many agencies involved with beach management, including the Army Corps of Engineers and local governments. The responsible agency would not be exclusively prone to providing piecemeal engineering solutions to problems as they arise, but would anticipate problems, manage land uses, and consider "do nothing" decisions as viable alternatives. (The Public Works Agency is in the process of developing plans for implementing this option, as recommended by the County Coastal Study.)

AIRCRAFT ACCIDENTS

Success/four flights Thursday morning/all
against twenty-one-mile wind/started from
level with engine power alone/average speed
through the air thirty-one miles/longest fifty-
nine seconds/inform press/home Christmas.

Wilbur and Orville Wright
Telegram from Kitty Hawk, N.C.
December 17, 1903

GENERAL DISCUSSION

GENERAL DESCRIPTION

This portion of the element is not required to be included in the Seismic and Safety Element. However, during the preparation of the noise element for the General Plan it was evident that there is a concern for safety problems near airports. The concern was great enough both locally and generally that it was decided to take the opportunity to ascertain the existing hazard level.

In assessing the history of aircraft accidents it was discovered that they are a relatively rare occurrence. A nationwide survey shows that there was 1.38 accidents per million operations at controlled airports. At the Ventura County Airport there was one accident during 1972 and 1973, which involved an experimental aircraft referred to as the "Flying Pinto." However, the accident rate at Santa Paula and Santa Susanna was much higher. There were seven accidents at each of those two airports during 1972 and 1973. An analysis of the individual airports, however, shows that such problems can be realistically predicted and mitigated.

Aircraft accidents can affect both the occupants and the area impacted. If a pilot has engine failure or for some reason must abort his flight, he will attempt to direct the craft away from structures and land in a clearing. However, if no such area exists, he has no choice but to possibly impact a structure in which death, injuries and property damage may result.

Aircraft accidents have a variety of causes; some are due to mechanical failure, but most are due to pilot error. Although some accidents may be prevented by restricting building heights, smoke and distracting lights on the ground, it is not possible to eliminate all accidents. In fact, everytime an aircraft takes off or lands there is the potential for an accident.

An accident can occur at any stage in a flight, however, analysis of accident data have shown that 62% of all aircraft accidents occur within one mile of the airport, while 48.5% of all accidents occur on airport property. In another analysis it was shown that 60% of all "near-airport" accidents occur within narrow bands at the ends of the runway. (Elroy, 1973, p. 1, p. 5)

Besides the statistical data, an understanding of aircraft operations makes it clearer why more accidents occur on or near airports, than in other locations. An in-depth analysis of aircraft operations was conducted by Maurice A. Garball, Inc. for the Santa Clara County Airport Safety Study and is summarized below.

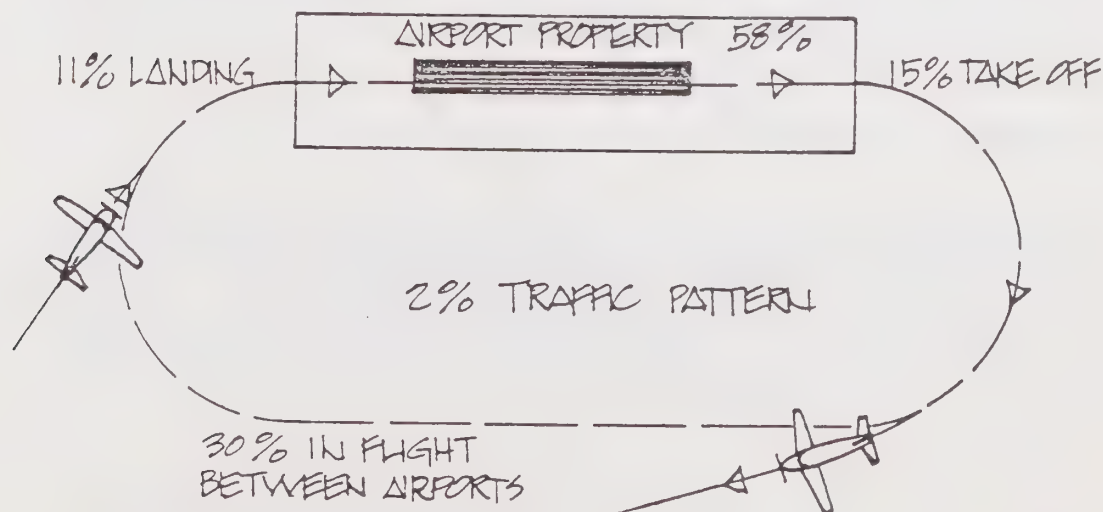
During the flight the most critical stages are the initial climb and final approach. The initial climb which involves the greatest thrust of power in order to obtain lift-off speed, may lead to mechanical failure. Federal regulations assume a height of fifty feet must be reached at the end of the runway in order to maintain flight. If the pilot has to abort the flight during take-off he will have to either emergency or crash land some distance off the end of the runway.

During the landing phase, accidents result from the misjudgement of the final-approach slope or speed, or the inability to prevent a premature touchdown by increasing power and thrust. Such problems are mitigated by the use of instruments and visual landing guides. The problems of take-off and descent are further complicated by the possibility of human errors.

The possibility of an accident hazard exists while the aircraft is in flight. However, the flight cannot be realistically regulated by land use controls and the non-concentration of accidents during this phase shows a relatively low hazard level impacting the general population.

Additional accident data from the National Transportation Safety Board's 1974 publication shows that for small fixed wing aircraft accidents (90% of the total accidents) 2% occurred in the traffic pattern compared with 11% in the off-airport portion of the landing phase, and 15% during the off-airport portion of the take-off phase.

Illustration 7.1
Location of Accidents



GENERAL EFFECTS OF THE HAZARD

PRIMARY EFFECTS

The primary effects on the ground of aircraft accidents are injuries to people and damage to property in the area of impact. The severity of accidents varies greatly, depending on the weight, speed, and fuel load of the aircraft. The amount of destruction resulting from an accident also depends on the land use in the impact area. Fewer lives would be threatened by a crash into a single-family house than by a crash into a school.

SECONDARY EFFECTS

The secondary effects of aircraft accidents are more difficult to assess. It appears that some residents in the areas under flight patterns are often fearful of planes crashing into their houses. Combined with the problems of noise, this fear can result in a decline in residential land values near airports and pressures from residents to end or restrict airport operations.

DURATION

The duration of the hazard is permanent. A threat exists every time an aircraft makes its initial climb or final approach over an inhabited area.

GENERAL INVENTORY OF THE HAZARD

LOCATION OF THE HAZARD

The areas most likely to be affected by aircraft accidents are the areas in the vicinity of the county's four airports: the County Airport in Oxnard, Santa Paula Airport, Santa Susana Airport in Simi Valley and the Point Mugu Naval Air Station.

HISTORY OF THE HAZARD

In 1972 and 1973 there were 15 civilian aircraft accidents in Ventura County which were near or on airports. (Near airport accidents comprise over 60% of all accidents according to national statistics.) Of these, 7 were at Santa Paula and 7 at Santa Susana Airports. The other accident occurred at Gonzales Road, a little over a mile from the County Airport.

In the first 4 months of 1974 there were 3 accidents near Santa Paula Airport (one into South mountain, one into the Santa Clara River, and one into a vacant house at the east end of the runway) and 2 near Santa Susana Airport. In the past 5 years there have been 5 near-airport accidents at Point Mugu, 3 on-base and 2 in the duck ponds about a mile away.

From an analysis of 1970 national accident data, an Assembly Committee on Natural Resources and Conservation report calculated that within a mile of airports there is a mean accident rate of 1.38 accidents per million operations (an operation is a takeoff or a landing). For the years 1972 and 1973, Ventura County's accident rate is significantly higher than this figure (19 per million operations), due to the high accident rate at Santa Paula and Santa Susana Airports. These 2 airports are used for recreational flying and do not have control towers, which increases the hazard.

Although there are far fewer accidents at the County Airport, a hazard may still exist there. Using the national accident rate of 1.38, it has been calculated that there is a 20% probability of an accident occurring within 1 mile of the County Airport over a year's time.

Aircraft accidents are relatively rare, and when they do occur there are usually no injuries on the ground. The pilot usually has some control over where he crashes and will try to avoid populated areas when possible. However, major disasters can occur, especially when there are large concentrations of people near airports. For example, in 1972 a jet in Sacramento crashed into an ice cream parlor at the end of a runway, killing 22 people inside the building.

DEFINITION OF THE HAZARD ZONE

Hazard zones have been identified for the 4 airports within the County (See hazard plate IV). These zones represent the general areas most frequently impacted by aircraft emergency or crash landing during the take-off or approach phase. They also represent the areas which based on aircraft operations and accident probability, should be controlled for the safety of persons both on the ground and in the aircraft.

The hazard zones used for the Point Mugu Naval Air Station are taken from the Navy's accident potential zones, which were developed from an analysis of all Navy aircraft accidents for 5 years. For the other airports, generalized hazard zones have been identified by the staff of the Planning and Airport and Harbor Departments.

The determination of the hazard areas are based on landing and take-off patterns and clear zones extending beyond the runway as recommended by the FAA and A Study on Airport Safety for Santa Clara County. The conical hazard zone is 1,500 feet wide around the ends of the runways and fans out from each end of the runway to include the descent and approach aspects of the flight patterns.

For general aviation airports the hazard zone generally extends from the end of the runway 1,500 feet in width and 3,500 feet in length. Open space uses in this area is critical, to ensure that options are available to pilots in emergency situations.

Landing and take-off patterns have been indicated on the hazard plate to show where a concentration of aircraft movements exist. But as stated earlier very few accidents occur in the pattern (2%) and as such the area under this pattern was not included in the hazard zone.

NATURE OF INFORMATION

The studies from which the hazard areas were determined were all based on national accident data. While this data provides a good picture of average hazard areas, conditions may vary for specific airports. More precise hazard areas could be determined by taking into account accident history, type of aircraft, number of operations, degree of instrumentation, weather and wind patterns and topography for each airport. Such detailed analysis is beyond the scope of this study but may be undertaken to some extent by the VCAG Airport Land Use Commission study.

GENERAL MANAGEMENT RESPONSIBILITY

INVESTIGATION

The National Transportation Safety Board collects data on the facts and circumstances of all civilian aircraft accidents and regularly publishes compilations of the statistics. The Navy keeps its own accident records.

REGULATION

The Federal Aviation Administration sets standards for the height of structures and hills near airports, which are aimed at preventing accidents by assuring a clear airspace. The FAA can only enforce its regulations at public airports, but the State Department of Aeronautics, which has similar standards, can refuse certification to private airports used by the public. In addition, the County, Oxnard and Santa Paula have ordinances restricting the height of structures around airports.

Regulations to further protect people on the ground are up to local governments and the County Airport Land Use Commissions (created by State Legislation), which have the responsibility of assuring compatible land use around airports. Ventura County APLUC is presently in the process of developing a plan for the County Airport and eventually will complete plans for the other airports. Once a plan is completed, all area plans and zone changes in the airport area will have to be approved by APLUC, unless its decision is overridden by a 4/5 vote of the City Council or Board of Supervisors.

ALLEVIATION

No matter what safety precautions are taken, there will always be occasional accidents near airports. The only way of alleviating the hazard to people on the ground is to keep them out of the area. This may be accomplished through careful land use planning, which is the responsibility of APLUC and local government.

LOCAL DISCUSSION

LOCAL INVENTORY OF THE HAZARD

Part of the hazard zones of each of the county's 4 airports lies in the unincorporated area of the county. The exact location of the hazard zones is shown on the Hazard Plate IV.

LOCAL RESOURCES AFFECTED BY THE HAZARD

The small unincorporated areas in the hazard zones, in the vicinity of the County and Santa Paula Airports are mostly in agriculture or vacant. The Point Mugu hazard area is primarily agricultural but also includes part of the Ventura County Game Reserve and a very small residential area. The small county hazard zone of Santa Susana Airport is vacant.

FINDINGS

PROBABILITY OF OCCURRENCE

Accidents occurring in the vicinity of airports are rare. There is a 20% probability of an accident occurring at the Ventura County Airport over a year's span, based on national statistics. The potential for an accident exists with every operation, but the probability is affected by the number and type of operations, weather and topography of the area and the surrounding land uses.

SEVERITY OF THE HAZARD

Existing land uses in the county areas of the hazard zones are primarily in agriculture and open space. Continuance of these policies will insure that hazard areas if developed, will be developed to low densities keeping the severity of a potential accident to a minimum.

RESOURCES AFFECTED

County areas of the airport hazard zones are largely in agriculture and open space uses, and therefore, few people or structures are found within the hazard zone.

NATURE OF THE INFORMATION

The hazard boundaries were defined through the use of national accident data and analysis of aircraft operations. More precise hazard areas could be determined through detailed analysis of each airport - the numbers and types of operations, weather conditions, and their factors. Such a study may be undertaken by the VCAG Airport Land Use Commission. This information, while generalized for general aviation airports, provides some basis for making planning decisions related to land uses.

OPTIONS

The following are a variety of alternative responses or "options" to this hazard. The appropriateness of each option will depend upon the specific conditions spelled out in the FINDINGS section and the feasibility of implementation of the option.

1. Remove residential structures adjacent to the ends of runways.
2. Recommend that a control tower be built on the airport if none exists.
3. In hazard areas, limit land uses to low intensity uses, such as: *
 - a) agriculture
 - b) recreational parks (low intensity use)
 - c) storage of seasonal equipment
 - d) auto parking
 - e) single story warehouses
 - f) municipal and industrial activities, subject to:
no more than 10 persons on an annual average
and no more than 25 persons at one time on each
net acre (10/25 population density).

*From Santa Clara County Land Use Plan for Area Surrounding Santa Clara County Airports.

LIQUEFACTION

and 10, there was a great earthquake...
and every mountain and island were moved
out of their places.

Revelations, Chapter 6
Verses 12 & 14

GENERAL DISCUSSION

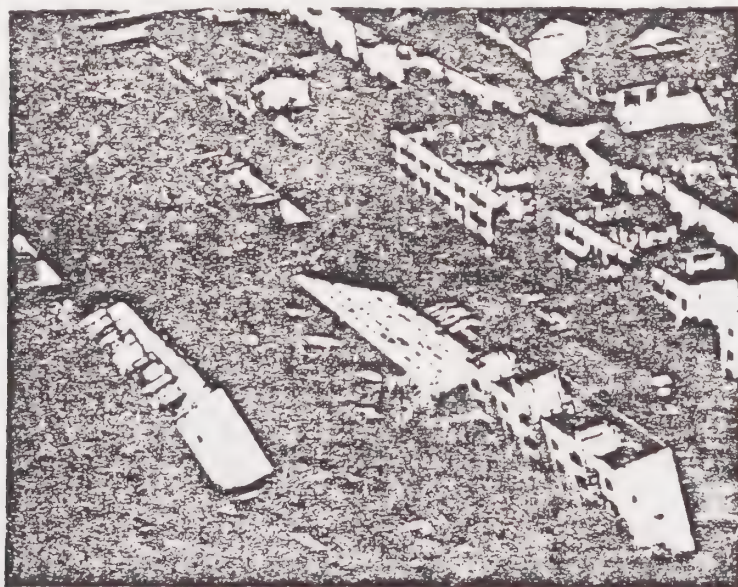
GENERAL DESCRIPTION

By far the greatest threat from an earthquake is the ground shaking that is produced and the resulting direct and indirect effects on manmade structures. In some earthquakes ground shaking results in ground failure, which can have catastrophic effects on structures. Ground failure is most often caused by liquefaction and can occur on relatively level ground.

Liquefaction can occur when loose cohesionless, uniform soils saturated with water are subjected to ground shaking of high enough intensity and long enough duration. Liquefaction is manifested either by the formation of sand boils and mudspouts at the ground surface and the seepage of water through ground cracks, or in some cases, by the development of quicksand-like conditions over substantial areas. When the quicksand-like conditions occur, buildings may sink substantially or tilt into the ground (see illustration 8.1 and lightweight buried facilities may float to the surface. (Seed, 1969) Other manifestations are landslides which can move hundreds of feet and lateral earth spreading of tens of feet.

Illustration 8.1

Tilting of apartment buildings, Niigata, Japan (1964)



A number of conditions are necessary to produce liquefaction. These include low density of the soil, uniformity of grain size, confining pressure, saturation of the soil materials with water, the intensity of the shaking and the duration of the shaking. In terms of density of soil, loose soil materials are most subject to liquefaction. Uniformity of grain size, such as a deposit of only sand, causes materials to be more susceptible to liquefaction than well graded materials. The deeper in a soil zone, which is susceptible to liquefaction, the higher the confining pressure will be and consequently, the potential for liquefaction is reduced. The soil must be saturated with water for any other conditions to apply.

Depending upon the confining pressure and the specific soil conditions, a certain intensity of shaking is required to trigger liquefaction. Intensity depends on the magnitude of the earthquake and the amplification of the ground shaking. Finally, the duration of the shaking is also important, as it takes a certain number of cycles of ground shaking for liquefaction to occur. The landslides of the 1964 Alaskan Earthquake did not occur until 90 seconds after the shaking started (Seed and Indriss, 1972). As compared to the 1971 San Fernando Valley Earthquake, where landslides were triggered after only 30 seconds of shaking.

Technically speaking, when a saturated sand is subjected to the necessary amount of ground shaking, it tends to compact and decrease in volume; if drainage cannot occur, the decrease in volume increases the pressure of the contained water. If the pressure reaches a point equal to the over-burden pressure, the sand loses strength completely, and develops into a liquefied state (Seed, 1969).

Liquefaction can occur at any level of a deposit but usually occurs within the first 40-50 feet. The potential for liquefaction exists wherever there are saturated loose sand deposits, especially if they are near the surface.

GENERAL EFFECTS OF THE HAZARD

PRIMARY EFFECTS

There are two major kinds of liquefaction. The first is where surface or near-surface liquefaction of soils occurs. Structures whose foundations are within such a liquefaction zone lose support under part or all of their foundations, which causes them to tilt or settle into the ground surface. If a building is not designed to take this amount of stress, the entire building may collapse. A partially liquefied layer can also flow out from under the weight of the foundation with similar settling effects. As a general rule, for structures not designed against liquefaction, the larger the structure the greater its potential for settling through liquefaction during an earthquake. Thus, while differential settling may affect almost any structure, smaller buildings such as single family frame homes are not likely to suffer major damage except in situations where the water table is less than fifteen feet from the surface. Larger buildings not designed against liquefaction, however, can be severely affected at almost any level down to about forty to fifty feet below the surface, as loss of frictional support of deep pile foundations can occur. In addition, light sub-surface structures such as pipelines and storage tanks can float to the surface during the ground shaking, causing further damage and potentially widespread dislocation of services.

The second type of liquefaction occurs when the soil layer that liquefies is below the surface. As the soil compacts under the ground shaking of the earthquake, the hydrostatic pressure increases. This pressure is usually relieved by the flow of water and soil to the ground surface. If the flow is small and the areas localized, the effect on the surface is that of sand boils and mudspouts which can last for a number of hours after the earthquake. However, if the flow is large and general, it will induce a 'quick' or liquefied condition at the surface, with the same results as surface liquefaction. If the subsurface liquefaction occurs on a slope, the liquefied layer can act as a lubricated plane for the layer above it to respond to gravity and move downhill. The effect is even more pronounced if the water cannot escape vertically and is forced horizontally along a contact surface. This type of liquefaction is a common cause of earthquake-induced landslides. Structures built across the edges of the slide are torn apart in much the same manner as if they were located on a fault (See illustration 8.2, p. VIII-6) a good example of this occurred

in the 1971 San Fernando earthquake where the Juvenile Hall slide was caused by liquefaction of a subsurface layer. An area of almost 163 acres moved down a 2.5% slope causing damage of over \$30 million. Movement down a slope with such a low gradient had not previously been recorded, but such effects must be considered in future earthquakes.

The liquefaction also often causes settlement of the soil. In Niigata, Japan, after the 1964 earthquake, settlement of over 3 feet was common. In Alaska, the ground around one wellhead settled 4.5 feet.

SECONDARY EFFECTS

Liquefaction could destroy or disrupt much of the infrastructure (i.e., gas lines, water, sewer, roads, etc.) in an area. Pipelines could be broken either by being floated to the surface or by landslide displacement. Bridge abutments could suffer differential settlement, cutting off roads. The settlement of large areas of land could drop some areas below sea level and produce a new shoreline, or at least require reconstruction to re-establish continuity of roads, etc. (see subsidence hazard).

GENERAL INVENTORY OF THE HAZARD

LOCATION OF THE HAZARD

The hazard exists wherever there are certain soils, particularly loose sand soils, that are constantly or seasonally saturated with water. This might include most of the river valleys and the low lying plains areas that have poor drainage (Hazard Plate V). Since subsurface soil properties are not precisely known, it is necessary to assume that all alluvial areas having high groundwater may be subject to liquefaction during strong earthquake shaking.

Most of the Oxnard Plain and Pleasant Valley have these characteristics and therefore, must be considered to have a very high liquefaction potential. Virtually all of the low lying areas in the Ventura River drainage appear to have these characteristics as does most of the Santa Clara River. Simi Valley appears to have a high liquefaction potential in both the east and west basins and the latter has water wells that are freely flowing at the present time. Most of the remainder of the Calleguas Creek areas appear to have adequate drainage to avoid the hazard, except for the lower Arroyo Conejo.

The lower Arroyo Conejo may have an increasing problem because the discharge from the Thousand Oaks sewage treatment plant contributes to higher groundwater levels in the western Santa Rosa Valley area and along the Arroyo further to the west. Thousand Oaks may have problems in the low lying valley areas, including Hidden Valley, because of their alluvial nature.

Most of the beach areas of the County including the entire coastline from Point Mugu to and including the Ventura River delta are probably underlain by loose water-saturated sands and other alluvial deposits which could be subject to liquefaction during strong earthquake shaking. Low-angle landsliding or lateral spreading along the beach areas could occur as a result of liquefaction of these deposits. In addition, landsliding could occur within and adjacent to the submarine canyon areas (see Hazard Plate V).

HISTORY OF THE HAZARD

Liquefaction has not yet been a damaging hazard in Ventura County, but along with its attendant ground shaking, it is possibly the biggest seismic threat in the County.

Some experience from other areas will possibly provide an insight into the potential effects of liquefaction on Ventura County. The effects of liquefaction was well illustrated by the Niigata earthquake of 1964 (See illustration 8.1). The structural damage was severe and there were numerous other damaging effects such as sand eruptions, water flows, landslides and settling of the ground surface.

In the Alaskan earthquake of 1964, there were numerous bridge foundation settlements, but the most severe damage was from the Turnagain Landslide, which was caused by liquefaction (See Illustration 8.2). The most startling discovery of the 1971 San Fernando earthquake in regard to liquefaction was that major slides could occur on slopes with an inclination as low as 2.5%.

Locally, liquefaction occurred in Calleguas Creek, Mugu Lagoon and the lower Santa Clara River during the February 21, 1973, Point Mugu Earthquake. The effects were mainly the development of minor ephemeral features such as shallow cracks and sand boils, but as Morton and Campbell point out in their report (California Geol., Dec. 1973) if the "shaking had been more severe, such effects might well have been widespread and could have resulted in significant agricultural crop losses". Also, the effects on structures could have been significant also.

Illustration 8.2

Eastern Portion of Turnagain Slide



SOURCE: U.S. Army photograph

Illustration 8.3

Turnagain Heights, Anchorage



This photo well illustrates the spectacular slide damage caused by the March 27, 1964, earthquake to the roadway and homes in this suburban development.

Eyewitness reports of the effects of the 1857 Fort Tejon Earthquake (magnitude + 8.0) on the San Andreas Fault suggest general liquefaction occurred along the Santa Clara River, along with other damage.

DEFINITION OF THE HAZARD ZONE

Since soil properties are not precisely known all alluvial deposits must be considered to be subject to liquefaction until investigation proves otherwise. Consequently, areas which are designated as within the high hazard zone are alluvial areas which have had water table levels within 15 feet of the ground surface at some time in the last fifty years or since well records have been kept. The moderate hazard is defined as including alluvial areas which have had water between 15 and 40 feet of the surface.

Large areas of the county have a surface layer of unconsolidated sand deeper than 40 feet and the entire county is susceptible to possibly severe earthquake shaking. Therefore, the primary variable factor for liquefaction in the County is the depth of the water table. The water level varies, but to be conservative, the highest level was selected. This is reasonable in urbanized areas where the water table is usually rising due to a number of factors including; curtailment of pumping; importation of increased amounts of water; reduced evaporation due to paving; heavy irrigation from watering of yards; percolation of sewage, etc.

The threat posed by this hazard varies depending upon the seasonal water level in some areas. The hazard zones designated assume that water levels are at their highest.

The significance of the water level being less than 15 feet from the surface is that in this range even small structures such as single family residences could be affected by liquefaction. This is the level at which the most severe liquefaction damage occurred in the 1964 Niigata, Japan earthquake. The 40-foot level corresponds to approximately the deepest level at which liquefaction most commonly can occur and is the level above which most building foundations are constructed, except for important structures.

NATURE OF THE INFORMATION

Data on the water surface level was taken from the extensive well records maintained by the Hydrology Section of the Ventura County Department of Public Works. These well records include up to 50 years of actual measurements at approximately one-month intervals.

Certain areas did not have usable well records. For these areas, either other special reports were used or actual field data was collected. One of the areas so field checked was Pleasant Valley. Alluvial areas are shown on Plate I of the State Division of Mines & Geology report entitled: Geology and Mineral Resources Study of Southern Ventura County (1973).

GENERAL MANAGEMENT RESPONSIBILITY

INVESTIGATIVE

The Ventura County Department of Public Works and the Public Works Departments of the various entities have primary responsibility for further investigation of the liquefaction hazard. The California Division of Mines and Geology in their cooperative study during the next year will investigate the hazard further. The California Department of Water Resources and the U. S. Geological Survey have ongoing projects to study groundwater and water table levels that affect liquefaction potential. Further research by federal and state agencies should be undertaken to more precisely determine the location and magnitude of the hazard as well as possible methods to counteract it.

ALLEVIATION

There is little that can feasibly be done to reduce the regional hazard. Important or critical structures can utilize special designs to alleviate the effects of the hazard except possibly in areas subject to landsliding. Land use controls are the only other methods available to reduce the threat to life and property. Whether or not land use controls are instituted by the Planning Commissions and City Councils or the Board of Supervisors depends upon these entity's perception of the probability of the hazard occurring, the costs of restricting land uses and their concept of acceptable risk.

Present Subdivision, Grading and Building Ordinances require geologic and soils hazards, such as liquefaction, to be considered in the design of land developments and construction of important or critical structures as well as single family homes where necessary.

LOCAL DISCUSSION

LOCAL INVENTORY OF THE HAZARD

The hazard exists throughout the Oxnard Plain and Pleasant Valley. The hazard zones extend up the Ventura and Santa Clara Rivers, mainly in the areas underlain by extensive alluvial deposits. Some of the valleys in the Thousand Oaks area are also affected as is the Arroyo Santa Rosa downstream of the Thousand Oaks Sewage Treatment Plant. Simi Valley is affected at both the east and west ends. Both the upper and lower Ojai Valleys are in the hazard zones as well as San Antonio Creek from Ojai to the Ventura River. The low lying areas north of Lake Casitas are also affected by the liquefaction hazard zones. There are other scattered areas also affected by the hazard zones, they are usually in stream canyons, tributary to the major areas.

LOCAL RESOURCES AFFECTED BY THE HAZARD

Within the County, a number of resources could be affected by the liquefaction hazard. These include natural, human and man-made resources.

Many riparian (streamside) areas could be disrupted by liquefaction in case of major shaking. These areas include (1) San Antonio and Thatcher Creeks; (2) Ventura River; (3) Lake Casitas and low lying areas of the Casitas watershed; (4) the Santa Clara River and Piru Creek area; (5) Calleguas Creek including Arroyo Simi from Simi Valley to Virginia Colony; (6) Arroyo Conejo from the Thousand Oaks sewage treatment plant through most of the Santa Rosa Valley; (7) Mugu Lagoon and coastal areas north of the lagoon which were originally tidal estuaries and (8) coastal beach areas.

Other areas may also be affected by liquefaction. The areas located within the hazard zones illustrated on Hazard Plate V, especially those areas of high hazards, could be disrupted by liquefaction. Agricultural crops may be particularly affected. There is also a possibility that portions of the western Camarillo Hills, western Ventura area, coastal beach areas, and areas within and adjacent to the submarine canyons off of Point Mugu and Port Hueneme could be subject to liquefaction-induced landslides as a result of high ground moisture or high groundwater levels.

In terms of loss of lives or injury occurring from liquefaction hazards, a threat exists in the county areas of the Oxnard Plain, Pleasant Valley, the Ventura River flood plain and in Newbury Park. In addition, those communities located in the Ventura River flood plain having concentrations of population, especially in single family homes may be affected.

The most severe threat exists in those structures used by concentrations of population. For example, at least seven schools that could be affected by liquefaction, although they are in the moderate hazard zone are: De Anza Junior High and all of the schools of the Rio School District, and Rio Mesa High School. The Briggs Road Industrial Park is located in the high hazard zone as are the nearby industries in the county areas of Saticoy.

All communities and facilities mentioned above could suffer heavy property damage in the event of severe liquefaction. Other areas that could be affected include: (1) Ormond Beach Generating Plant and most of the high voltage transmission lines on the Oxnard Plain and crossing the Santa Clara and Ventura Rivers; (2) most of the oil facilities along Ventura Avenue, and (3) the entire Point Mugu Naval Air Station. There are also numerous pipelines and other underground utilities that could be affected on the Oxnard Plain, in Thousand Oaks and near the rivers.

The structures and areas listed above are simply those that are located within the boundaries of the hazard zones on Hazard Plate V. The information used to define the zones was the best available but does not allow precise delineation of hazard areas. Also the boundary lines represent a transition zone which fluctuates seasonally and with changes in water supply. Therefore, those facilities listed are not the only ones that could be affected by the hazard. These, however, should be studied first when alleviation of the hazard is considered because of the higher probability of them being affected by the hazard.

FINDINGS

PROBABILITY OF OCCURRENCE

A liquefaction threat may exist in the entire hazard zone identified in Hazard Plate V. Liquefaction has occurred in this area and can be expected to occur again whenever an earthquake of sufficient intensity occurs. According to many experts, a major earthquake on the San Andreas fault in Southern California, is possible within the next fifty years; other smaller earthquakes are also quite likely.

SEVERITY OF THE HAZARD

The most severe hazard exists in areas of loose alluvium and high groundwater levels, but lessens progressively in areas of more compacted soil and/or where water levels are lower. The severity of the effects depends upon soil properties and intensity and duration of the shaking and the resultant type of ground failure. If general surface liquefaction were to occur, most structures in the hazard zone could be affected to a greater or lesser degree.

RESOURCES AFFECTED

Most of the river valleys are susceptible to liquefaction as are agricultural areas on the Oxnard Plain and in Upper and Lower Ojai Valleys. Those residential areas on the Oxnard Plain, Pleasant Valley, the Ventura River and in Newbury Park included within the high hazard zone and those industrial facilities in the same areas could possibly sustain major property damage in case of general liquefaction.

NATURE OF INFORMATION

The water table levels in alluvial areas were arrived at by taking the highest figure measured from the extensive records of the Hydrology section of the County Department of Public Works. The boundaries of the hazard zones are only approximations and are not accurate enough upon which to base any building code requirements. In addition, the estimated effects of liquefaction may vary greatly within a given zone during a given earthquake. Any specific conclusions should be

reached on the basis of detailed site-by-site soils and geologic studies.

OTHER FINDINGS

Special attention should be given with regard to the existence of the liquefaction potential in evaluating the adequacy of existing important or critical facilities in the high hazard areas, since the threat may be quite severe, especially to larger buildings and other critical facilities and structures. Proposed developments must presently meet the requirements of numerous ordinances enforced by the Departments of Public Works and Building and Safety which require consideration of various conditions including potential liquefaction.

OPTIONS

The following are a variety of alternative responses or "options" to the hazard. The appropriateness of each option will depend upon the specific conditions spelled out in the FINDINGS section.

1. Encourage performance of regional studies by qualified Federal and State agencies such as the U. S. Geological Survey and the State Division of Mines and Geology or private research firms in order to more accurately determine areas of potential soil liquefaction hazards.
2. Encourage and participate in cooperative studies with the above agencies.
3. If necessary, retain private consultants for more detailed study and determination of areas of potential soil liquefaction hazards and any possible methods of alleviation.
4. Consider evaluation of existing critical structures, facilities and foundation conditions for cases where their susceptibility or resistance to soil liquefaction is unknown and, if necessary, locate vital facilities and emergency services outside of the high hazard zone.
5. Encourage State or Federal agencies to undertake or sponsor research in design and construction to develop methods of providing greater resistance of structures to withstand the effects of soil liquefaction.
6. Adopt the Uniform Building Code and the additional provisions of the County Subdivision Ordinance, Building Regulations and the Land Development Manual or equivalent requirements for all land development.
7. Provide adequate enforcement of the aforementioned requirements by requiring that each proposal for land development be reviewed by qualified personnel registered and certified by the State such as professional engineers, and engineering geologists.
8. Adopt current investigation guidelines, such as those published by the Structural Engineers Association of Southern California (Technical Appendix), for proposed land development within the High or Moderate Liquefaction Hazard Zones and for all major projects.

9. Require geologic-seismic and soils engineering investigation of soil liquefaction potential for all proposed structures whose failure could result in danger to life and property or great monetary loss.
10. Adopt mitigating measures in the high or moderate hazard areas, such as modification of existing or proposed structures and facilities, improvement of emergency action plans and implementation of any possible controls for activities which could aggravate the condition locally.

TSUNAMI

"Wherein I spoke of most disastrous chances of moving
accidents by flood and field of hair-breadth 'scapes i'
the imminent deadly breach"

Othello I
Shakespeare

GENERAL DISCUSSION

GENERAL DESCRIPTION

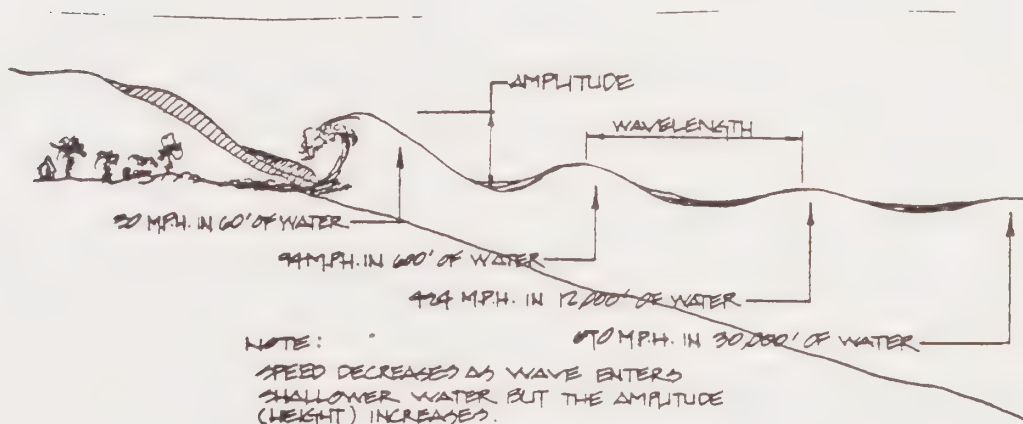
PHYSICAL PROPERTIES

Tsunamis (pronounced soo-nom-ee) are large ocean waves that are generated by submarine landslides, volcanic eruptions or earthquakes in or near ocean basins. These waves are commonly referred to by the general public as tidal waves.

The term "seismic sea wave" applies to a tsunami caused by an earthquake. These waves have a long wavelength (distance from the crest of one wave to the crest of the succeeding wave), normally over 100 miles and a very low amplitude (height from crest to trough).

As these waves approach shallow water, the speed decreases from a deep water speed of over 600 m.p.h. to less than 30 m.p.h. as they move across the beach. The energy however, is transferred from wave speed (velocity) to wave height (amplitude) and waves as high as 100 feet can be formed.

Illustration 9.1
Characteristics of a Tsunami or Seismic Sea Wave



The waves can arrive on shore in intervals of up to an hour and since there are usually a number of waves in a set (rather than just one) the threat usually exists for as long as 10 to 12 hours. Tsunamis are sometimes preceded by a trough which frequently brings the curious down to the shore to examine what appears to be an extremely low tide. The wave itself, may follow the trough by 15 to 45 minutes. Tsunamis can also travel considerable distances inland on waterways, particularly those with shallow gradients.

DETECTION

The Seismic Sea Wave Warning System (SSWWS), directed by the Coast and Geodetic Survey, is the primary source of tsunami detection. This system has been in operation since 1948. The SSWWS and cooperating foreign countries operate a system of seismographs and tide stations. This system includes automatic seismic alarms that are triggered whenever an earthquake of sufficient magnitude to generate a tsunami is recorded, since earthquakes produce the vast majority of tsunamis. The SSWWS Honolulu Observatory determines the location of the quake by using the local arrival time of different earthquake waves. If the quake is in or near the Pacific Basin a Sea Wave Advisory is issued, along with estimated times of arrival of tsunamis. (See illustration 9.2)

Although the arrival time of waves can be predicted, the intensity of the wave when it reaches shore cannot be predicted. Until the 1960 Chile tsunami, which caused hundreds of deaths in Japan, it was not known that a tsunami of such distant origin (10,000 miles) could produce such devastating effects in Japan. In other instances, extensive damage can occur in one area while causing negligible damage in adjacent areas.

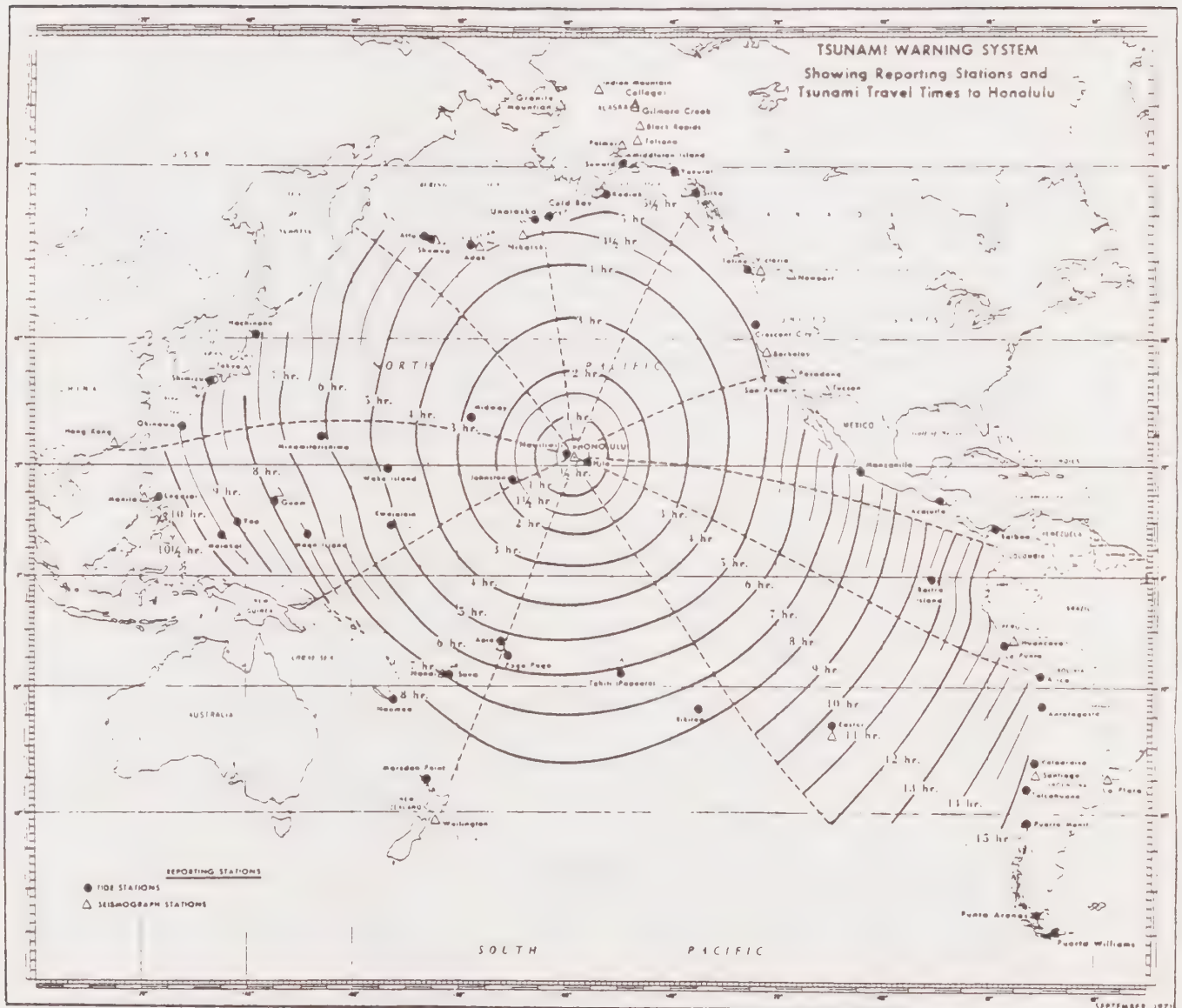
GENERAL EFFECTS OF THE HAZARD

PRIMARY EFFECTS

Tsunamis are a threat not because they are so extensive or frequent, but because the destruction they cause can be devastating. The danger is also compounded by the fact that the intensity of the wave is unpredictable and the threat is intermittent over many hours.

The tsunami threat is mainly confined to the immediate beach areas, except in river channels. Beach areas have been affected up to a mile or more inland in very flat areas.

Tsunami Warning System Map, showing reporting stations and Tsunami travel times to Honolulu from possible distant origins of such waves.



Source: National Oceanic and Atmospheric Administration - NOAA.

Tsunamis can also proceed up flowing rivers for many miles if the gradient of the river is shallow. The effects of the waves are most noticeable on man-made features and these effects are usually temporary. But the waves can also change river channels and modify coastal landforms and these effects are noticeable for many years. There is no way to avoid the damage to features in the path of a tsunami, but when there is enough time for a warning to be issued, there should be no loss of life if the necessary precautions are taken. These waves are not common in California and, therefore, the recurrence interval seems to be large; however, the historical record is not extensive enough to develop predictions.

SECONDARY EFFECTS

The immediate or primary effects of a tsunami are easily visualized but the secondary effects can be unanticipated. Water systems can be contaminated, power disrupted, transportation systems blocked or dislocated, increased occurrence of fires from broken oil and gas tanks or lines, flooding from blocked rivers, etc.

DURATION

The assault on the shoreline from a tsunami is relatively shortlived, but because the waves come in succession over a period of up to 10 to 12 hours the duration of the threat is quite long.

GENERAL INVENTORY OF THE HAZARD

LOCATION OF THE HAZARD

All of the coastal areas in Ventura County are susceptible to tsunamis. A tsunami from the north Pacific could move down the Santa Barbara Channel and affect the northerly coastal areas; a seismic sea wave from the South Pacific or from South America could strike the County coastal areas from the south to southwest; and a tsunami generated along one of the faults within the Santa Barbara Channel could affect much of the County coastal areas. The Channel Islands do not provide adequate protection for the County coastal areas.

HISTORY OF THE HAZARD

The worst recorded tsunami to hit California was in 1812. An earthquake occurred in the Santa Barbara Channel, and the resulting waves are reported by some disputed sources to have been up to 50 feet above sea level at Gaviota (Richter, Pg. 113),

35 feet above sea level at Santa Barbara. They were probably at least 15 feet above sea level at Ventura.

Crescent City has been the scene of numerous recorded seismic sea wave incidents. Widespread damage and some loss of life occurred in 1964 following the Alaskan Earthquake. Tsunamis from that earthquake also destroyed a number of towns in Alaska and caused over \$1/3 million damage to the Los Angeles-Long Beach harbors and approximately \$35,000 damage to the marinas in this County. The marina damage in Ventura County, which was mainly to the channel banks, was caused by the rapid and extreme changes in sea level.

The historic record indicates that there is a small probability of occurrence of a major tsunami in Ventura County. Statistically it has been over 160 years since the last major tsunami; but many smaller, unrecorded tsunamis may have occurred.

DEFINITION OF THE HAZARD ZONE

The uncertainty of local effects makes the definition of the hazard zone difficult, but the east-west trending faults in the Santa Barbara Channel area seem to intensify the hazard parallel to them, thus increasing the possibility of high waves in the north and south coast areas.

The hazard zone defined by this study, therefore, includes all areas of the County up to 20 feet above sea level and within one mile of the mean high tide line. Areas of exception are: east of Point Mugu and north of the Ventura River where the zone includes all areas up to 30 feet above sea level and up to 50 feet above sea level, respectively.

The basis for the location of the hazard zone on the Oxnard Plain is the estimated 15-foot high wave of 1812. To be slightly conservative, however, the hazard zone in this region is extended up to 20 feet in elevation. This estimated level will allow for the probable subsidence of the plains area as well as a possible rise in sea level since 1812. It is possible that waves larger than those ever recorded could occur, but there is no way to predict what level they would reach.

The recommended areas of evacuation in the event of a tsunami are all areas below the aforementioned elevations or within a mile of shore (whichever is of the greatest inland extent), and two miles inland on the Santa Clara River, Ventura River, and Calleguas Creek. The reason for extension of the zone two miles upstream from the mouths of these watercourses is that a tsunami can generate a bore (a wave moving upstream) in flowing water and travel farther inland.

(See Plate V)

NATURE OF INFORMATION

Information on the tsunami of 1812 is from mission records at Santa Ynez, Santa Barbara, and San Buenaventura. The most recent information seems to discredit much of the information from Santa Ynez and Santa Barbara since it was from witnesses whose remembrances were recorded many years after the event. However, the records from Ventura were recorded at the time of the event and are believed much more accurate. The historic data on tsunamis in Ventura County, while limited, is generally accepted as accurate. With other factors taken into consideration, the hazard zone was defined using the latest geologic data and is the best estimate obtainable using the given data.

GENERAL MANAGEMENT RESPONSIBILITY

There is no known way to end or even to feasibly mitigate the tsunami hazard. Since the occurrence of tsunamis are very infrequent and many of them can be predicted hours ahead of time, a warning system seems to be the best method of alleviating the hazard.

INVESTIGATION

Research on tsunami hazards is continuing on virtually all levels of government. UNESCO's International Oceanographic Commission (IOC) has established an International Tsunami Information Center in Honolulu, to promote further research and exchange of information concerning tsunamis. The National Ocean Survey (NOS) and U.S. Coast and Geodetic Survey (USCGS) of the National Oceanic and Atmospheric Administration (NOAA) are the primary investigators of tsunamis in the U.S. The U.S. Geologic Survey (USGS) is also assisting in the basic research of processes involved in the generation of tsunamis. The California Division of Mines and Geology is investigating the extent of hazard to California. The Division will generally investigate the threat to Ventura County as part of the special geological investigation they will undertake in Ventura during the latter part of 1974.

WARNING

Warnings of impending tsunamis are generated by the USCGS Seismic Sea Wave Warning System (SSWWS) and the Alaskan Regional Tsunami System. They issue both Seismic Sea Wave Advisories, when an earthquake of significant magnitude has occurred in an area susceptible to tsunami generation, and Seismic Sea Wave Warnings, when tide stations confirm the generation of a tsunami (See illustration 9.2).

These Advisories and Warnings are transmitted by NOAA Satellite to the California Office of Emergency Services (OES). These warnings are evaluated by the Warning Control Officer and Director of OES and if necessary a statewide warning is issued to the local Sheriff, along with the estimated time of arrival of the wave. (See illustrations 9.2 & 9.3). Ultimately, the Sheriff has complete responsibility whether to alert the coastal areas. If it is decided that an evacuation is necessary, the Sheriff will call the Police Departments of Oxnard, Ventura and Port Hueneme, the Highway Patrol, Fire Department, and the Director of Disaster Services. After this is accomplished, appropriate jurisdictions and departments are alerted. It is the responsibility of each jurisdiction to decide whether or not their population will be alerted. Ultimately, the evacuation of the coastal areas (See Plate V) is voluntary on the part of the residents. The alerting agencies can only warn people of the hazard--they cannot force evacuation. However, they can control re-entry into a hazard area.

Unfortunately, neither the Seismic Sea Wave Warning System nor any other known means of monitoring can provide sufficient warning time to allow for evacuation of coastal areas should a tsunami be generated along one of the faults within the Santa Barbara Channel. The arrival time for such a wave at any point on the coast would only be a matter of minutes. The only warning prior to arrival of a possible tsunami would be the ground shaking experienced from the earthquake. Such shaking would be felt in advance of the tsunami arrival and, if heeded, could allow sufficient time for people to move to higher ground.

ALLEVIATION

The threat to human life can be nearly eliminated by an effective warning system when advance notice is available. The county territory as well as the cities of Oxnard and Port Hueneme have an efficient warning system in effect which can alert the entire affected population, if enough warning time is available (refer to Warning section). Because advance notice may not always be possible (such as in the case of a tsunami originating in the channel), and because warning systems cannot alleviate the threat to property, various jurisdictions may wish to evaluate land uses as a means of insuring minimal loss of life and property. As indicated earlier, there is a small probability of the occurrence of a tsunami in Ventura County. Therefore, the most practical means of alleviation is an effective warning system. Whether or not land use controls are employed by the various jurisdictions depends upon its perception of the probability of the hazard occurring and the costs of restricting certain land uses.

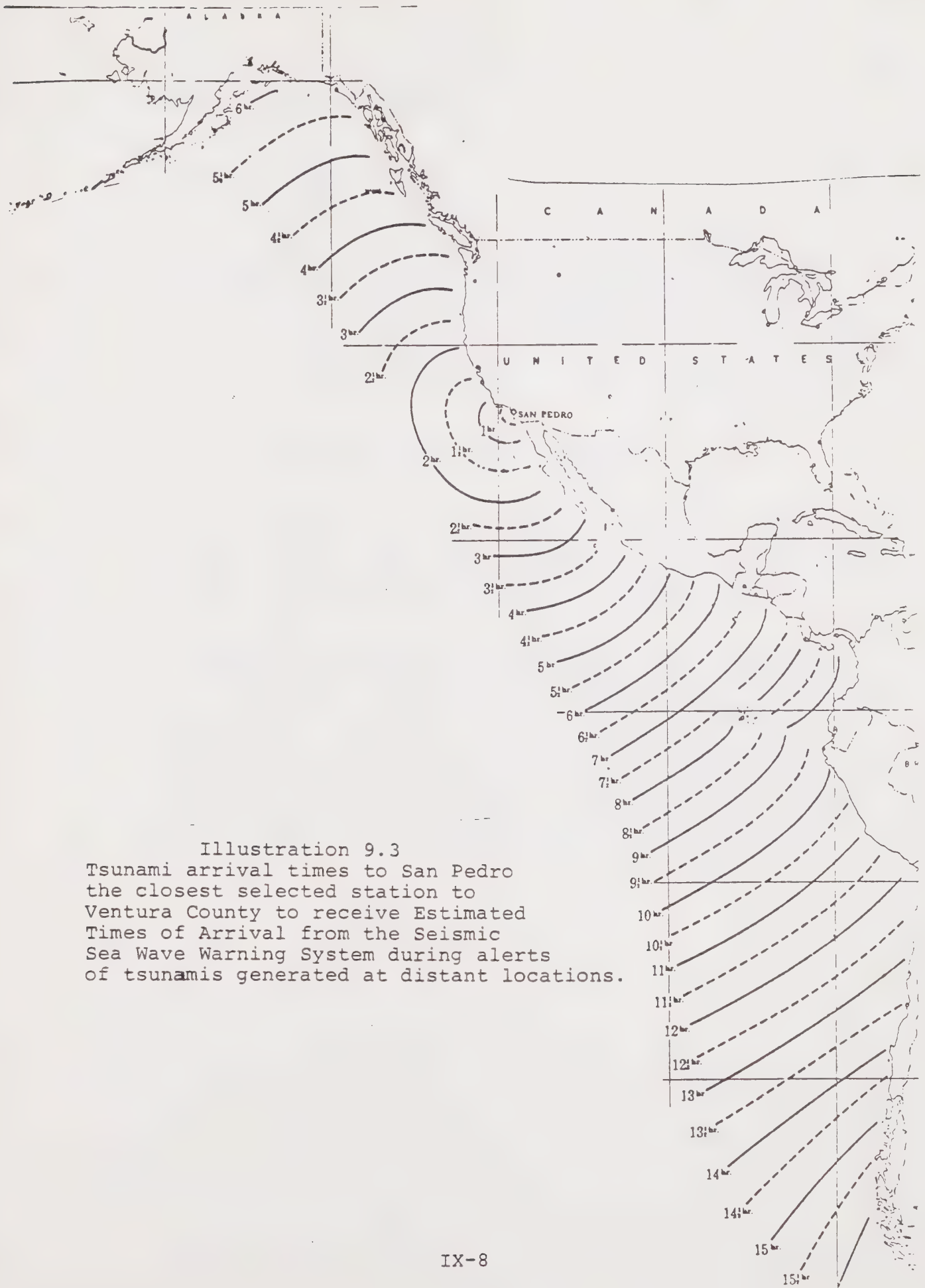


Illustration 9.3
 Tsunami arrival times to San Pedro
 the closest selected station to
 Ventura County to receive Estimated
 Times of Arrival from the Seismic
 Sea Wave Warning System during alerts
 of tsunamis generated at distant locations.

LOCAL DISCUSSION

LOCAL INVENTORY OF THE HAZARD

Most of the land between the beach and the cliffs on both the North and South coasts is included within the hazard zone. The hazard zone from the Santa Clara River to Point Mugu extends inland approximately one mile. Also the zone extends two miles upstream from the mouth of the Ventura and Santa Clara River and Calleguas Creek. (See Plate V for the specific boundaries of the hazard zones).

LOCAL RESOURCES AFFECTED BY THE HAZARD

While natural features may be destroyed by tsunamis, they will usually recover. The water courses for the Ventura and Santa Clara Rivers and Calleguas Creek may be altered and their bio systems temporarily destroyed. There are likely to be similar effects on Mugu Lagoon.

There are a number of small communities within the County whose residents could be affected by a major tsunami. These include, on the north coast (west to east), Rincon, Del Mar (Bates Point), La Conchita (Punta), Mussel Shoals (Punta Gorda), Sea Cliff, Faria and Solimar (Deulah). Moving south, the areas of Hollywood-by-the-Sea, and Silver Strand in Oxnard, and scattered multiple dwellings on the south coast could suffer damage. During the summer months, many people camp at several parks within the hazard zone. These include: Hobson, Faria, Emma Wood, and Point Mugu State Park.

FINDINGS

PROBABILITY OF OCCURRENCE

A tsunami threat exists to the entire unincorporated county coastline. Based upon historic record, the probability of a major tsunami hitting Ventura County seems remote, but due to their unpredictable nature, a tsunami could occur at any time. The last major wave struck the county in 1812, but minor tsunamis have been recorded as recently as 1964.

SEVERITY OF THE HAZARD

Historic records in Ventura County (and throughout the world) reveal that the severity of tsunamis vary greatly, but that a major tsunami could cause extensive damage within the designated hazard zone and possible loss of life if the warning system is inadequate.

RESOURCES AFFECTED

In the event of a major tsunami, loss of life and property damage would not be as great in unincorporated areas as in the incorporated cities. Nevertheless, numerous small coastal communities could be affected as would many oil production and storage facilities, vital transportation links, and recreation facilities.

NATURE OF INFORMATION

The validity of conclusions arrived at in this study of tsunamis is a function of the information from which they were derived. It should be noted therefore that while local data is limited, it does provide a basis for making general indications of the areas that would be affected by a major tsunami and that damage would occur.

OTHER FINDINGS

Since tsunamis themselves cannot be eliminated, the alternative means of reducing the hazard would be through the protection of people and property. Unless a tsunami originated from within the Channel, or another area close to the County, there would generally be adequate time to warn people and thus prevent any loss of life. While warning systems can alleviate the loss of life, it does not prevent property losses. Land use controls are another method of alleviating the hazard that can reduce the possibility of damage to property or loss of life when there

is not time for general warning. The entity making the determination of the use of land use controls, must take into consideration the infrequency of recent occurrences the lack of detailed information from the historic record and the appropriateness of the controls.

OPTIONS

The following are a variety of alternative responses or "options" to the hazard of tsunamis. The appropriateness of each option will depend upon the specific conditions spelled out in the FINDINGS section.

1. Develop a tsunami warning plan similar to the County's Basic Plan.
2. Review contingency plans for tsunami and update if necessary.
3. Review and carefully delineate areas to be warned and evacuated under the tsunami warning plan.
4. The hazard zone delineated on Plate V should be adopted to replace the one used in the Basic Plan.
5. Develop contingency plans for alerting owners of boats in the marina so that boats can be removed to open sea.
6. Review the possibility of a practice exercise to acquaint responsible personnel with warning and evacuation procedures.
7. Develop a program through individual mailings and/or public meetings to acquaint the public located in the hazard zone with the warning plan and the procedures for its implementation.
8. Investigate the possibility of ordinances to protect existing sand dunes as possible barriers to tsunami inundation.
9. Change the name of the County Basic Plan to Tsunami or Seismic Sea Wave Warning - Evacuation to avoid using the mistaken term "tidal wave."

SEICHE

The long light shakes across the lakes,
and the wild cataract leaps in glory.

Tennyson

GENERAL DISCUSSION

GENERAL DESCRIPTION

A seiche (pronounced sāsh) is a wave or series of waves or oscillators, set up in an enclosed or partially enclosed body of water by wind, earthquake or landslide. In a large body of water, wind can set up an oscillation that will send waves above the normal water line. These oscillations can be visualized by imagining a pan of water that is gradually tilted until waves start to slosh out. This type of seiche usually occurs only when the body of water is located in an unusual position in relation to local wind patterns.

The most common seiches are set up in lakes and bays, either directly or indirectly by earthquakes. The shaking of an earthquake can set up large and destructive oscillations that can send waves tens of feet above normal lake level. In harbors and bays, these waves can destroy harbor and shore facilities. Indirectly, tsunamis, by causing a rapid change in sea level or more commonly by the wave itself, can set up smaller internal oscillations in bays and harbors. These seiches are very similar to tsunamis, but the waves are smaller and of lower energy. Fault displacement under a reservoir can either displace a quantity of water or tilt the lake bed suddenly, producing waves by either effect. Earthquakes can also trigger landslides and these, whether triggered seismically or in some other manner can be by far the most destructive type of seiche (see Landslide/Mudslide Hazard). A landslide into an enclosed body of water can produce massive waves, especially on the shore opposite the slide.

Although it is possible to measure the slow ground surface movement that sometimes precedes a landslide, in general, methods for the detection of landslides and other seiche-producing agents are still under study.

GENERAL EFFECTS OF THE HAZARD

PRIMARY THREAT

The primary threat from a seiche is to structures and facilities in or very near a lake, harbor or bay. Boats and their wharfage can be heavily damaged by seiches, and buildings and campgrounds can be inundated. Only in the case of an extremely severe seiche, a rather rare occurrence, would loss of life be likely from the seiche itself. This is not the case, however, with the secondary effects.

SECONDARY THREAT

The secondary effects of a seiche can often produce more damage than the seiche itself. Large seiches can overtop the dams of man-made lakes and reservoirs, causing flooding in the areas downstream. This overtopping can also wash out earth-fill dams, causing their complete collapse.

The extent of most seiches is small, usually no more than ten to twenty feet above water level, and the duration is short, usually only a few minutes. However, a landslide can displace a wave that could travel hundreds of feet up the opposite shore of a body of water. Also, tsunami-caused seiches can last for many hours due to the possible rejuvenation of the seiche by each passing tsunami crest; however, each seiche would last only a few minutes and be of decreasing severity.

It appears that the actual threat that is posed by seiches is small, and it is probably the most remote of the hazards studied, although it may not be the least severe.

GENERAL INVENTORY OF THE HAZARD

LOCATION OF THE HAZARD

The hazard exists in all the lakes in the county, the two marinas and the harbor. The lakes that are impounded by earth-fill dams could have the greatest hazard potential. These lakes are Lake Bard (Wood Ranch Reservoir), Lake Piru and Lake Casitas. The Santa Clara River Valley could also be affected should a seiche-caused dam failure occur on Castaic Reservoir or Pyramid Reservoir. (See Plate V)

HISTORY OF THE HAZARD

No recorded seiche has ever occurred in Ventura County, but the damage to the marinas from a seiche could possibly be similar to that caused by the tsunami of 1964 (see Tsunami Hazard).

In Italy, in 1963, a landslide into Vaiont Reservoir caused a seiche that traveled up 800 feet on the opposite bank of the lake and swept over both abutments of the dam (the world's highest thin arch concrete dam) to a height of 328 feet. The water completely destroyed the town of Longarone below the dam, with a loss of over 2,000 lives. After all this, the dam itself was still standing.

DEFINITION OF THE HAZARD ZONE

The hazard zone surrounds all of the existing reservoirs and lakes, the harbor and the two marinas, up to an elevation of 10 feet above the water level. The ten foot figure is an estimate due to lack of information about the hazard.

NATURE OF INFORMATION

There is very little information available on seiches. There is no historic record of seiches occurring in Ventura County. Due to the indefinite nature of the triggering mechanisms, it seems doubtful that enough information will ever be known for general prediction of the hazard for planning purposes.

GENERAL MANAGEMENT RESPONSIBILITY

There is no way to alleviate the effects of possible seiches except by prohibiting construction within the hazard area. The State Division of Mines and Geology will in a general way, examine the hazard further within the next year.

RESOURCES AFFECTED BY THE HAZARD

The boat ramps and the campgrounds at Lake Casitas and Lake Piru are in the hazard area. Some of the homes at Lake Sherwood could be inundated during a seiche. The homes, boat docks and boats at the two marinas and at Westlake could also be affected, as could the wharfage and facilities at the Port of Hueneme. In the case of a seiche-caused dam failure, all the areas below that dam could be affected.

FINDINGS

A hazard from seiches does exist in the County, but the threat is considered remote. Only facilities in, or very near, enclosed bodies of water could be immediately affected. The over-topping of dams by seiches, however, could cause significant adverse effects down stream.

OPTIONS

The following are a variety of alternative responses or "options" to this hazard. The appropriateness of each option will depend upon the specific conditions spelled out in the FINDINGS section.

1. The seiche hazard should be considered in all development within the hazard zone.
2. Limit development in landslide hazard areas around water bodies subject to seiche.

SUBSIDENCE

Every valley shall be lifted up
and every mountain and hill
shall be made low, the uneven
ground shall become level and the
rough place a plain.

Isaiah, Chapter 40
Verse 4

GENERAL DISCUSSION

GENERAL DESCRIPTION

Subsidence, or the sinking of the land surface, is a worldwide problem. In Japan, nearly three million people in Tokyo and Osaka now live in areas below the high tide level. (California Geology, p. 149). Mexico City has subsided twenty five feet. (Geology, Seismicity and Environmental Impact, 1973). Numerous other examples exist which can be related to human activities.

In California, four types of subsidence caused by human activity, have been identified (in addition to those forms of the hazard which occur naturally). Named according to the action which causes the subsidence, these four are: Groundwater Withdrawal Subsidence, Oil or Gas Withdrawal Subsidence, Hydrocompaction Subsidence and Peat Oxidation Subsidence. Of all of these types, Groundwater Withdrawal Subsidence, which generally occurs in valley areas underlain by alluvium, is the most extensive and the impacts most costly. (Urban Geology, p. 43).

Basically, the process by which this first and most important type of subsidence occurs involves the extraction of a large quantity of water from an unconsolidated artesian aquifer. As this water is removed from the aquifer, the total weight of the overburden which the water used to help to support, is placed on the alluvial structure. Where this is unconsolidated, it can be compressed.

If fine-grained silts and clays make up portions of the aquifer, the additional load can squeeze the water out of these layers and into the coarser grained portions of the aquifer. All of this compaction produces a net loss in volume and hence a depression in the land surface. A very similar sequence of events leads to subsidence with oil and gas withdrawals (California Geology, p. 148).

Current studies of this problem in the state, focus on the determination of six factors. These are: degrees of groundwater confinement, thickness of aquifer systems, individual and total thickness of fine-grained beds, compressibility of the fine-grained layers, probable future depth of wells, and probable future decline in groundwater levels. All of these have a direct bearing on the potential occurrence and severity of withdrawal subsidence but the primary causes are substantial or initial (first-time) reductions in the water level of a valley fill alluvium. The two other forms of subsidence, peat oxidation and hydrocompaction, are rather localized and no evidence exists which indicates their occurrence in Ventura County (Urban Geology, p. 47).

Though the focus of this discussion has been on that subsidence which is caused by human activities, it is important to understand that subsidence can and does occur as a natural process. Surface deformation can be the result of the natural compaction of loosely consolidated alluvium or tectonics. Subsidence has been traced to the settling of geologically new sediments and to downwarping which accompanies crustal folding.

Subsidence can also be caused by several kinds of natural processes. Perhaps the most hazardous for Ventura County is that which might be caused by seismic shaking in the area of the Oxnard Plain. That area is known to be subsiding, thus exhibiting an intrinsic instability. The addition of strong ground motion from an earthquake could result in the liquefaction of fine-grained materials. This would cause a loss of ground support and the land surface could settle (Seismic Hazards, 1974). Unlike other forms of subsidence, this one could occur in a short period of time.

In terms of controlling subsidence, it is important to recognize that combinations of the above types may cause the change in level in a specific area. Before any steps in controlling subsidence can be attempted, a comprehensive investigation into what the cause or causes are, will be necessary. If human activity, such as extraction of fluids, is determined to be the key then regulatory action could halt the subsidence. However, if natural processes are responsible, control is much less easily exercised assuming it is even possible.

PHYSICAL PROPERTIES

The surface deformation resulting from oil extraction has been described as "...differential subsidence of lands centering on the fields, inwardly directed horizontal displacement and faulting." (Urban Geology, p. 46). The first of these, differential subsidence, is both the most common and the most widespread surface manifestation of subsidence. A large bowl shape, extending beyond the production area is commonly identifiable.

Oil extraction has resulted in the greatest subsidence on record (elsewhere, not in Ventura County). In the Wilmington Oil Field, near Long Beach, a drop of 29 feet was recorded in the period 1928 to 1972. In 1966, a program of repressurization in conjunction with the secondary recovery of oil commenced which successfully halted the subsidence by 1972 (Urban Geology, p. 46).

A subsidence of similar magnitude occurred in the San Joaquin Valley. This was recorded in 1969. A key difference between this case and the previous one, however,

was that here the cause has been determined to be the extraction of groundwater (Urban Geology, p. 46).

MEASUREMENT AND DETECTION

Forecasting the extent, rate and magnitude of subsidence is difficult. A series of benchmarks must be established to measure any vertical change. This will, over time, provide information regarding the location of subsiding land and show that area which is subsiding fastest. From this point, core samples of the area would have to be compaction tested to determine probable future consolidation. Combining this information with fluid withdrawal rates (if any extraction is occurring) can make prediction about future subsidence possible. From this point, the desirability of either planning for the subsidence in terms of regulated land use or counter-measures to halt the subsidence could be assessed.

A successful attempt to reduce the amount of subsidence has been made in the Santa Clara Valley, south of San Francisco starting in 1964. While still sinking, a reduction in the rate of subsidence by about 95% was achieved when large amounts of imported surface water allowed a reduction in the tapping of the valley's underground sources. The water level subsequently rose about 60 feet. In a study of this process, a research hydrologist has concluded that a complete halt can be put to Santa Clara's subsidence and possibly a reversal can be achieved, if the water table is raised sufficiently. (California Geology, p. 148).

Another source lists the possible means by which withdrawal caused subsidence can be curbed. Prefacing these methods with the statement that any attempt to stop subsidence is a major undertaking, this article states that the technique employed depends on the structure of the aquifer. In areas of unconfined aquifers, reduced withdrawal or increased recharge through water-spreading is necessary. Confined aquifers or oil bearing zones must be repressured by injection wells in order to stop subsidence. Mainly, due to the high cost involved, this method has been used in only one instance in the area of the Wilmington Oilfield. (Engineering Geology, p. 278).

GENERAL EFFECTS OF THE HAZARD

As with the destruction which is caused by expansive soils, that caused by subsidence is generally not of an immediate or violent nature. Except when prompted by seismic shaking, the compaction of alluvium and settling of the land surface is a process which consumes years.

Undoubtedly, since most subsidence damage occurs very slowly over a long period of time, it is assigned an unwarranted lack of attention. Much money is lost through either premature abandonment or repair costs. It now appears that at least in the case of withdrawal subsidence, proper management could prevent continuing damage.

PRIMARY EFFECTS

Subsidence which results from groundwater withdrawal can be responsible for numerous structural effects. Most seriously affected are long surface infrastructure facilities which are sensitive to slight changes in gradient. Within this group, wells, canals, sewers and drains especially have experienced functioning and structural failure. In a 1970 projection, losses to the year 2000 were estimated to reach about \$26,000,000 for subsidence in California. Water withdrawal subsidence accounts for a large part of this. (Urban Geology, p. 11).

Subsidence caused by oil and gas extraction is similar in effect to that caused by water extraction. In one example, oil extraction was responsible for \$100,000,000 in damages to various facilities and structures in the Long Beach area. (Urban Geology, p. 48).

Hydrocompaction can also create subsidence conditions as can peat oxidation, the latter is a particular threat in terms of increasing the potential for flooding. (Urban Geology, p. 48). Both of these, however, are common only in areas outside of Ventura County so they are of minor or no consequence to us.

SECONDARY EFFECTS

Inundation must be viewed as a potentially serious secondary effect of subsidence in Ventura County. Both the ocean and the Santa Clara River could flood into depressed areas of the Oxnard Plain. If a naturally low area is further depressed by the action of subsidence, it is reasonable to assume that the damage will be more severe than if the subsidence had not occurred. In the case of the coastal portion of the Oxnard Plain, beach erosion could extend further inland due to the additional loss of elevation caused by subsidence.

The Santa Clara River poses another problem. It is building up sediments within its present course while no longer adding deposits to the remainder of the Oxnard Plain. If the old deposition sites have had an opportunity to consolidate and establish a gradient difference between themselves and the present river course, a flood could change the river course and thus inundate the lower

land. Extraction of oil and/or water could increase the potential for such an occurrence and increase the area affected if they added to the subsidence.

Numerous other secondary effects can be identified. Most of these are related to the disruption of services provided by various structures which might be damaged by subsidence. Those facilities most commonly affected are canals, wells, pipelines, drains, and related facilities.

GENERAL INVENTORY OF THE HAZARD

LOCATION OF THE HAZARD

A very significant area in Ventura County, the Oxnard Plain, is experiencing subsidence. This area has been monitored by the U.S. Coast and Geodetic Survey since the 1930's. Up to 1965, one large area was subject to subsidence of between 0.04 and 0.05 feet per year. (Coastal Geology, p. 5). A single point located at Hueneme Road and Highway 1 has dropped 1-1/2 feet in just twenty-one years. Records to 1968 show a dozen bench marks that have settled a foot in a fifteen to twenty year period.

Hazards Plate VI of the Seismic and Safety Elements shows three subsidence zones. These zones are: probable subsidence that is on the order of 0.05 feet/year; probable subsidence of less than 0.05 feet/year; and the estimated limit of areas presently affected by subsidence. The first and most severe of these categories reaches roughly from Pierpont in the north to the Mugu Lagoon in the south and extends east on the Oxnard Plain to the junction of Highways 1 and 101 (Public Works). The last two categories extend inland from the more severe subsidence on the Oxnard Plain ultimately up through the Santa Clara River Valley to a point just east of Piru.

NATURE OF INFORMATION

Definite and detailed establishment of the rate and/or cause of subsidence in Ventura County has not been made. Public Works information indicates four possible causes: natural consolidation of alluvium, tectonic deformation, water extraction, and/or oil extraction. The specific cause or causes of Ventura County's subsidence problem probably could be determined, but only after immense effort and cost. For example, such an analysis would necessitate detailed investigations over a 5 to 10 year period into such areas as fluid withdrawal - both amounts extracted and types of formation withdrawn from.

If, as a result of this analysis, it was found that human activities were responsible for the subsidence then measures could be taken to halt or even reverse the process.

Available evidence as to cause of subsidence in Ventura County is quite scanty; indeed, information is available only for groundwater. Current data suggests that groundwater has been extracted from the aquifers underlying the Oxnard Plain at a rate that exceeds the rate of replenishment. Overdraft of water for agricultural, domestic and industrial uses has increased from about 32,000 acre feet per year in 1959 to about 44,000 acre feet per year. The water table has dropped as much as 55 feet below sea level as a result of this continuous overdraft. (Water Quality Control Plan, p. 27). Despite the availability of groundwater data, the present lack of information on other causes precludes any meaningful assessment of actual cause of subsidence.

As part of a regional effort extending from Santa Barbara to Los Angeles, some 500 to 600 benchmarks are being monitored in Ventura County by a federal agency to determine the extent of subsidence. Readings were taken in 1970 and a second series, five years later, should result in a report on areas of significant change. While not aimed at identifying causes, this report coming out next year, will at least establish locations and amounts of subsidence (Powell).

The County Surveyor is participating in this program which is being conducted by the National Ocean Survey, formerly the U.S. Coast and Geodetic Survey. Preliminary data, though in no way conclusive or absolute, does indicate that subsidence is occurring on the Oxnard Plain. Secure figures on rate, amount and extent of the subsidence here and elsewhere, will have to wait until the publication of the 5-year report (Powell). Areas requiring more detailed studies could be determined based upon the information in the report.

Positive determinations regarding the exact limits and rates of subsidence would require special surveys for this particular purpose. Such a survey would require a grid of many bench marks (monuments) of special construction and a periodic monitoring program extending over a period of several years.

GENERAL MANAGEMENT RESPONSIBILITY

Studies of water withdrawal subsidence have been conducted by the U.S. Geologic Survey and the California Department of Water Resources. Adverse effects are moderated to some degree by State and Federal projects

which provide surface water to areas with dropping groundwater tables. In areas where such assistance is not available or where a project does not make up all of the difference, then control of the problem is responsibility of local water conservation districts. This control is both loose and variable (Urban Geology, p. 48).

Subsidence resulting from oil and gas extraction has been investigated by the U.S. Geologic Survey, California Department of Water Resources and the California Division of Oil and Gas. The Division of Oil and Gas has a monitoring and regulating program which the "Urban Geology" report ranks as equal to the task. Coordination with local agencies and expansion of the program to areas of need are the only changes the State has identified as necessary for proper control of this hazard. (Urban Geology, p. 11).

As stated previously, several agencies are involved in the control of this hazard in Ventura County. The first step in this direction, the inventory and investigation of subsidence, is being taken. When this effort is completed, a better understanding of the nature of the problem should afford the concerned agencies an opportunity to determine the need for special monitoring and, ultimately, to control and/or plan for it.

LOCAL DISCUSSION

Thus far, the only information available on subsidence in Ventura County has to do with its approximate rate and extent. No reports are available on causes or damage. Without this information, and because of the regional nature of this hazard, any statement about the danger which subsidence poses to the cities or specific locations within cities cannot be made other than those made about the County in general. Therefore, no local hazard sections are included in this report.

FINDINGS

PROBABILITY OF OCCURRENCE

A subsidence problem does exist; mainly in the Oxnard Plain area of the county. It is probable that it will continue, possibly at an increasing rate. This could occur if extraction of fluids from this area is increased.

SEVERITY OF THE HAZARD

Measurements to date indicate that a maximum drop on the order of 1.5 feet has occurred over the past 20 years in some areas of the Oxnard Plain. Further surveying is continuing and should better define the magnitude of this problem. Records from other areas of the country and the world indicate many areas experience much more severe subsidence problems than is the case in our county.

RESOURCES AFFECTED

Property damage due to subsidence can and does occur over a long period of time. Loss of life would probably occur only as a secondary effect of subsidence, say as the result of flooding. Drainage courses, wells and utility lines are potentially the most vulnerable to damage.

NATURE OF INFORMATION

A possibility exists that some potential subsidence damage can be controlled. Such controls, however, must await the definite determination of the cause or causes of subsidence, as well as the rate of this subsidence. Until this information is fully developed, little can be done to plan for or respond to this hazard. The current Water Resources Management Study being conducted by the State Department of Water Resources in cooperation with the County of Ventura and due to be completed in December, 1975, will provide additional information in regard to groundwater management.

OPTIONS

The following are a variety of alternative responses or "options" to this hazard. The appropriateness of each option will depend upon the specific conditions spelled out in the FINDINGS section.

Two major alternatives are available for preventing subsidence caused damage. The easier option would be to forego any attempt to better determine the rate, amount, extent and causes of subsidence, and make policy from the available information. Land use controls, for example, might be instituted, but without an adequate understanding of the dynamics of the local subsidence, long term changes in its effects could not be anticipated. This would, over time, greatly reduce the effectiveness of land use controls.

The second option involves electing to measure and study this phenomena. The amount of effort expended and the degree of study in such an analysis, of course, is variable. This would, if strongly enough pursued, result in a determination of cause or causes. With an understanding of this hazard, appropriate control measures could probably be established.

Since the removal of groundwater has been determined to cause or contribute to subsidence in other areas of California, consideration should be given to curtailing the further removal of groundwater at rates exceeding the natural recharge rate of the groundwater system. In addition, evaluation of potential subsidence could be required prior to approval of new water, oil or gas well drilling permits.

EXPANSIVE SOILS

Expansion means complexity and complexity decay.

Parkinson's third law

GENERAL DISCUSSION

GENERAL DESCRIPTION

Expansive soils (which are identical to soils referred to elsewhere as having a shrink-swell potential) are those which are generally clayey, expand or swell when wetted and contract or shrink when dried. Wetting can occur naturally in a number of ways, i.e. absorption from the air, ground-water fluctuations, as well as from other sources, i.e., lawn watering, broken water or sewer lines.

In the 1960's, expansive soils caused severe damage to many housing developments. While significant construction deficiencies were noted, more conservative engineering design provisions and regulations were initiated which effectively eliminated the hazard to future construction. Subsequent engineering studies have resulted in tests and design procedures which provide safe and economical design for expansive soils. Local building ordinances have incorporated these concepts in recent years.

The only area relating to expansive soils, which must continue to receive special attention, is downslope soil creep in hillside areas. As an expansive soil expands and contracts it tends to move downslope in response to gravity. Recognition of this condition by all parties should not be overlooked. This condition may require flatter slopes, soil removal and special landscaping and irrigation treatment.

The tremendous force exerted by the expansion of soils is generally not understood by the average person and quite often results in requests for waiver of the soil test as "unnecessary." Such a complacent attitude is unjustified. In no way should the ability to provide designs for expansive soils give one the feeling that expansive soils are no longer a factor to be considered.

GENERAL EFFECTS

Fully 20% of this nation's land area will be affected by expansive soil movements during the period of the average person's lifetime. Typically, expansive soils are located in areas of moderate slope which are coincidentally the areas generally most attractive for intense, urban type uses. The movement of expansive soil may be slow, progressing over a period of years. Commonly, this movement is associated with seasonal or even longer wet/dry cycles. (Civil Engineering, 1973, p. 49).

PRIMARY EFFECTS

These soil movements can cause structural damage to houses, pavement and utilities in two ways. First, the expansion of the soil can cause it to heave and thus place direct pressure on a structure. Alternately, soil expansion can lead to the loss of support under part of a structure. This can occur during swell conditions if the saturated soil shifts due to the weight of the structure, or in dry conditions if the soil shrinks and support is withdrawn.

Damage can range from the impaired functioning of doors and windows through plaster and foundation cracks to total destruction in extreme cases. Often water from a leaking sewer line is responsible for causing the soil expansion which damages a home. Annually, some 250,000 homes are built on expansive soils in the United States and 10% of these will experience "significant damage." Nationally, at least \$2.3 billion is lost annually due to damage to houses, buildings, roads and pipelines. Records exist of expansive soils causing damage to highways, buildings, reservoirs, swimming pools, canals and utilities of all types. (Civil Engineering, 1973, p. 49).

SECONDARY EFFECTS

The main secondary effect of expansive soils to structures not designed against the condition is monetary loss.

GENERAL INVENTORY

LOCATION

Three expansive soil zones have been mapped; and they appear on Hazards Plate VI. Derived from the Soil Conservation Service's 1970 Soil Survey, this map designates high, moderate and low expansive zones. This is a generalized version of individual soils maps. It generally indicates those areas where expansive soils are present. (See Soil Survey in Ventura Area, 1970).

A more specific map was prepared for each entity, and the degree of expansiveness may not conform precisely to Plate VI even though both utilize identical categories of expansive soils. The reason for this is that the local maps were taken from the non-generalized maps developed by the Soil Conservation Service and thus display a greater level of detail.

While the general and specific maps are quite useful for locating large areas of potential hazard, it must be stated that they cannot be used in lieu of site inspection when construction is considered. Experience in the Building and Safety Department indicates that a soils test at the specific site is necessary because this hazard is so localized in nature.

HISTORY

In the early 1960's numerous homes were lost and many more were severely damaged in the Shadow Oaks Tract. Adjacent to the City of Thousand Oaks, this area experienced soil expansion which cracked many 2-inch thick slabs. Other areas of the county have also experienced problems due to soil expansion, specifically the Camarillo Heights Area. However, here the damage has not been as great because many lessons were learned in the Shadow Oaks case.

As the damage started to appear in the new homes of this tract, many of them were vacated. Still others remained occupied but some people stopped making their payments. Many houses were rented, a transient group of people occupied these and the neighborhood generally declined.

In time, repairs saved some homes while others were replaced using more cautious construction techniques. The slabs were increased in thickness up to 9 inches. In time, this requirement was refined and relaxed in cases where soils tests revealed minimal shrink-swell potential. The Shadow Oaks case was primarily responsible for the establishment of more stringent building code requirements which have effectively eliminated the expansive soils problem in Ventura County.

NATURE OF INFORMATION

General information concerning the shrink-swell potential of the county's soils has been provided in the Soils Survey by the Soil Conservation Service. This information is useful but its limits must be recognized.

Expansive soil is so localized in occurrence that it is necessary to test each site and gauge construction to the specific soil conditions. A range of design requirements and construction techniques must be met according to the expansive quality of the soil. It appears that no further information is needed about the general occurrence of expansive soil in the county. However, investigation is needed for each site and this is being accomplished as specific proposals for development are made.

It is generally accepted that the expertise exists to both identify the problem and provide solutions. Soils engineers can locate problem areas and foundation engineers can design counter measures. The ability to control and minimize damage from expansive soils is such that the State in its Urban Geology Master Plan sees no need to either institute new or change existing programs. Merely implementing existing programs to their full extent is the recommendation of this State report.

GENERAL MANAGEMENT RESPONSIBILITY

INVESTIGATION

For the county in general, the United States Department of Agriculture and the University of California Agricultural Extension have investigated the occurrence of expansive soils in their Soil Survey. This investigation shows a scattering of such soils and thus indicates the necessity for individual investigations of local soil conditions. Building regulations in unincorporated areas require appropriate soils tests, but some city requirements are not always so stringent on this point.

REGULATION

Numerous agencies have established standards to eliminate the potential for structural damage due to expansive soils. Both HUD and FHA have codes to be followed if expansive soils are present. The United States Department of Agriculture in conjunction with the University of California Agricultural Extension Station have recommendations based on their Soil Survey of Ventura County. In addition, the State Subdivision Map Act and the Uniform Building Code exert some control in areas where this hazard exists. Various city and county ordinances similarly speak to this issue.

Within Ventura County a soils engineering report is required in certain cases when a tentative tract map is submitted to the County. It is necessary, according to Section 8225 of the County Ordinance, when a hillside area is part of the proposal. If expansive soils exist, the soils report should reflect this condition.

In the case of the construction of buildings, the County Department of Building and Safety requires a soils test for every unit in the unincorporated territory except for sandy beach areas.

ALLEVIATION

Steps would have to be taken in the grading and construction phases of a subdivision in order to assure protection against this hazard. Among the corrective measures which might be employed are various foundation construction techniques including proper drainage. The degree of expansiveness, as revealed in the expansion test, dictates the type of foundation design. If the expansiveness of a soil exceed a set limit, then a special engineering design is required for that site and building (Building Regulations, 1973). Responsibility for enforcement of County ordinances for grading rests with the Department of Public Works, and with the Department of Building and Safety for buildings (structures). Similar responsibilities rest with these respective departments of each city in the County, unless the city contracts with the County for services.

LOCAL DISCUSSION

LOCAL INVENTORY OF THE HAZARD

Expansive soils are scattered throughout the unincorporated areas of the County.

LOCAL RESOURCES AFFECTED BY THE HAZARD

The resources most often affected by expansive soils are structures. Even though expansive soils are scattered throughout the county, their potential impact on structures is limited to just a few developed areas: portions of the Ojai Valley, the Camarillo Hills and areas around the community of Moorpark. The presense of expansive soils in these developed areas presents no threat, however, because soils tests and engineering solutions can overcome the dangers of expansive soils.

LOCAL MANAGEMENT RESPONSIBILITY

The County Building and Safety Department oversees the building permit and inspection processes. These processes which have effectively ended the dangers of expansive soils, include soils tests at each construction site and the enforcement of building standards keyed to varying degrees of expansive soils.

FINDINGS

PROBABILITY OF OCCURENCE

Expansive soils exist in Ventura County. Soils of varying degrees of expansiveness can be found throughout most of the County. Especially with our seasonally rainy/dry periods, it can be assumed that local soils will have the opportunity to shrink or swell if they have significant clay content.

SEVERITY OF THE HAZARD

Historically, expansive soils have caused considerable damage in Ventura County. Since the initial damage in the early '60's, the problem has been studied and corrective construction techniques have been developed. This has allowed construction even in areas where the hazard is severe. Through proper investigation and design, the potential for damage can be eliminated.

RESOURCES AFFECTED

Damage in Ventura County was confined to a few areas but most notably was the Shadow Oaks tract near Thousand Oaks, where newly constructed houses were affected. Expansive soils are generally localized in occurrence so designations of hazard zones on a County scale are not usually adequate for purposes of providing protection.

NATURE OF THE INFORMATION

Basically, the information is available to protect property from damage caused by expansive soil. Soils tests can reveal if a problem exists and, if it does, the degree of hazard can be defined.

OTHER FINDINGS

Proper foundation construction can prevent damage if a threat is shown to be present. Therefore, the only action necessary to prevent damage, is a process which requires the appropriate soils information be developed and applied to the specific site.

OPTIONS

Within the County, the control procedures should continue to be maintained at present levels. Reports indicate that damage is minimal throughout the County. Projecting this performance into the future, indicates adequate protection will be provided by this level of service.

Some cities do not approach this hazard with the same degree of caution as do other cities and the County. These cities, according to the available general information, have less hazardous conditions and have not as yet experienced any damage due to expansive soils. If new information is developed or if damage from expansive soils develops, these cities might develop more stringent programs.

DAM INUNDATION

Since potential dam failures affect the safety of many communities, inundation maps for all major dams are being prepared by the dam operators pursuant to section 8589.5 of the Government Code of California. These maps will become a mandatory consideration in the Safety and Seismic Safety Elements when the maps have been approved by the State Office of Emergency Services.

Preliminary maps are available for some of the dams affecting the county. Lake Casitas, the largest dam in the county is controlled by the Federal Bureau of Reclamation and they cannot be compelled to do the inundation maps. However, they have indicated that they will prepare one next year. Castaic and Pyramid Dams, in Los Angeles County but upstream in the Santa Clara River drainage system, are operated by the California Department of Water Resources as part of the California Water Projects. These maps are in preparation but the State refuses to release the preliminary maps.

The maps for the three largest dams that effect the county are not available and all the rest are only preliminary and subject to change. Since they are not yet required and the information is preliminary, it was decided to delay the inclusion of this hazard section until the final maps are received, probably sometime in 1975.

This hazard has more relevance to Ventura County than almost any other area of the State because of the 1928 failure of the St. Francis Dam which caused massive destruction in the Santa Clara River Valley. This dam failure was the second worst disaster, in terms of the number of lives lost, in California history; second only to the 1906 San Francisco earthquake. This section will be added to the Seismic and Safety Element as soon as the final maps are available. The State does not require this section as part of the element until the final maps are received.

FIRE HAZARD

(Parve saepe scintilla contempta magnum excitavit incendium)

A small spark neglected has often kindled a mighty conflagration.

Quintus Curtius
1st Century A.D.

GENERAL DISCUSSION

GENERAL DESCRIPTION

Ventura County is a very pleasant place, both to live and to visit. The climate is warm and dry with gentle winter rains and clear summer skies. The view from the few flatlands in the southern part of the county is spectacular with rugged hills and mountains in most directions. The hills are green (or if not grassy, at least golden) all year long with brush and oaks at the low elevations and pine forest at the ridge tops. However, these same characteristics, in most senses, are clearly amenities, that make it one of the most hazardous fire areas in the country.

The climate in this area is generally referred to as "mediterranean" with rainfall concentrated in the most efficient months, during the cool winter when there is less evaporation. The rainy winters are caused by the dominance of cool, moist northern Pacific weather, which is characterized by the frequent passage of storm fronts followed by clear and temperate periods. These winter rains are stored in the ground and in the vegetation to assist it over the summer drought. The rains usually stop sometime in May and there is a drought, often lasting into November. This summer drought is the dominant characteristic of this climate. It is caused by the tropical desert air patterns that are dominant during this time period. Actually, this simplified model is not entirely correct, since the alternation of seasonal patterns is rarely exact and in consequence there is a high variability of rainfall and dominant weather patterns.

A local variation which aggravates the already fire hazardous situation is a local weather phenomenon that often occurs in Southern California when a low pressure trough develops off the coast and high pressure settles over the Great Basin of Nevada and Utah and over the deserts of eastern California and Arizona. The normal westerly wind flow is reversed and air pours in from the north and east, out of the deserts, down into the coastal basins and valleys. These are the Santa Ana winds which funnel through the mountain passes, growing warmer by compression as they descend. These winds arrive hot, dry and charged with static electricity and carrying dust. The extreme dryness, down to 1 percent or less relative humidity, desiccates the vegetation already dried by the drought.

This natural Southern California vegetation has adapted to this summer drought cycle. The annual plants, grass and wildflowers, mainly pass through the active phases of their life cycles in early spring, go to seed and die in early summer. While their demise is aesthetically pleasing, turning the hills golden and brown, the dry grass substantially increases the fire hazard. The perennial plants also have special adaptations to resist the drought. Most are naturally desert plants such as the sage that dominates in the coastal sage vegetation association, the sagebrush found in the yellow pine belt and the yucca which occurs in the chaparral. Their special adaptations include slow growth, small leaves and the abilities to both shed a portion of their leaves during summer drought and to develop waxy coatings on leaves to cut down evapotranspiration. Unfortunately, these latter two adaptations are major contributors to the extreme flammability of the chaparral and other plant associations which cover most of the steep hills between the beach and the pine covered hill tops.

Geologically speaking, the hills themselves are young and rugged, as witnessed by the fact that the sharp corners have not been worn off. These hills are still undergoing uplift at a rate of at least 25 feet per thousand years. Since the maximum rate of erosion is about 7.5 feet per thousand years (Erosion and Sediment Yields, U.S.G.S.), this means the streams are eroding, mainly by cutting straight down into their channels to produce deep canyons with steep precipitous sides. Given the combined effect of uplift and erosion, Ventura County tends to have a hilly landscape with very steep slopes.

Wherever these steep slopes are covered with the chaparral vegetation, after a few months of drought the fire hazard becomes extreme. It should be noted, however, that fire is a normal condition in Southern California. If it were not for the recurrent fires the chaparral would slowly be replaced by Oak woodland, a grassland with scattered live oak trees. Since man is the main cause of wildfire, it is perhaps appropriate that he is the main one affected. This is no new occurrence, of course, since it has been true since aboriginal man first arrived in this area. The Amerindian populations regularly deliberately lit fires to drive out game. These fires probably were the major contributing cause for the modification of the vegetation from oak woodland to chaparral.

Ironically, the longer an area goes without burning, either of chaparral or one of the other vegetation communities, the more fuel (both dry, dead material and growing plants) there is ready to burn. Thus, the more effective we are in preventing fires, the more likely they are to occur!

Fuel for fires is usually ignited by man, either directly by an arsonist, children playing with matches, individuals carelessness in smoking, debris burning, fireworks, campfires, and the like, or indirectly through accidents by man-made objects such as falling power lines, explosion of heaters or fuel tanks or by sparks from equipment hitting rocks or from engine exhaust. Natural causes, primarily lightning, are now relatively minor causes of local fires.

Although many fires are started every year, fortunately very few of them actually develop into major brushfires. The optimum conditions for large fires are: heavy vegetation with a thick layer of dead material, extreme dryness (usually found toward the end of summer) and high winds to provide abundant oxygen. These latter are usually Santa Ana winds, which also contributes to the dryness, and ignition. The resulting fire can spread very rapidly, at times consuming as much as 3,000 acres an hour. The steep hills help the spread of the fire by allowing it to burn rapidly up hill and frustrating fire suppression attempts. The worst condition exists whenever fire storms develop, large vortexes that concentrate heat and develop their own winds. Fire storms, which can jump freeways and the largest fuelbreaks, are almost impossible to control until weather conditions change.

Responsible public agencies in California, in general, and Ventura County in particular, have developed elaborate systems for fighting brush fires. When weather conditions become severe, all fire fighting personnel are put on alert. When a fire starts, all available personnel are rushed to the scene to keep the fire from developing into a major blaze. If the fire does get out of control and more than the county's own resources are required, mutual aid agreements are in effect with neighboring cities and counties to send additional aid. If the situation becomes a major problem, the State and even Federal aid is available for suppression of the fire.

Fire safety in urbanized areas must be evaluated in different terms than wildland fires. In this element, the aspects of fire protection in urban areas will be limited to an evaluation of evacuation routes, peak load water supply requirements, minimum road widths and clearances around structures. When discussing structural fires these points can be addressed in the same manner as wildland fires except for evacuation routes, which are defined in terms of removing the occupants from a burning or endangered building as opposed to evacuation from an area.

GENERAL EFFECTS OF THE HAZARD

PRIMARY EFFECT

In the short run, fire has its most widespread effects on the natural environment. However, a more detailed examination indicates that in some ecosystems wildfires in the longer run are actually beneficial. The chaparral associations (coastal sage, oak woodland, etc.) contain large numbers of pyrophytic plants, that require fire to reproduce or thrive, plus other plants that are resistant to fire using a number of adaptations. When these vegetation systems burn, the individual plants, and their associated animals are destroyed but the association survives and is actually improved by this natural selection.

A good example is the Potrero Fire that burned Point Mugu State Park in 1973. The scene was one of complete desolation following the fire. All the vegetation, including the Sycamores and Oaks, were burned and hundreds of small animals were killed. A month later, deer and birds were abundant and other animals were also on the rise. The burned remains of the brush was root sprouting (with the deer eating the shoots) and most of the burned trees were resprouting leaves. The vegetation and animals are projected to be back to normal in about three years but with the plants thinned out and the excess animal population culled, to the advantage of both.

Damage to man-made improvements account for most of the dollar loss from wildfires (aside from immediate suppression costs). The estimated value of the watershed lost forms the remainder of the total cost of the fire loss. Although developments in the hillside areas have a high value because of the view they provide, they are all too often built in dangerous brush covered areas. The ridge tops naturally provide more flat areas for house pads, (plus have the best view) and often the developments are put there with the canyons left undeveloped, remaining in their native vegetative state. Another contributing factor in the fire hazard is that of wood shake roofs; while considered the most aesthetically desirable roofing materials, they are extremely flammable. When a fire starts it burns up the steep hills, toward hilltop homes, making cantilevered homes particularly susceptible to fire on their undersides. The shake roofs ignite and the burning shakes help spread the fire, especially to surrounding buildings. The Bel Air fire of 1961, burned through communities developed on ridge tops, adjacent to brush filled canyon. Of the homes and other structures in the area of the fire, most of which had a high proportion of wood shake roofs,

484 residences and 21 other structures were destroyed and over a thousand others damaged. Significantly lower amounts of damage were sustained by structures (1) having non-flammable roofs, (2) having good brush clearance, (3) having their own pumps (water pressure was usually inadequate) and water supplies and/or (4) not located directly adjacent to brush areas.

In terms of control and prevention, the clearance of brush from around these structures can keep the main force of the fire from the building. This procedure is ever more effective when accompanied by regular replanting and maintenances of the canyon areas to make them less susceptible to ignition. In addition, the prohibition of shake roofs (or at least their limitation by requiring that fire proof roofs be interspersed with shake roofs) can significantly limit the spread of fires in new subdivisions. The maintenance of personal fire protection capability, such as gasoline pumps for using swimming pool water, reserve water supplies, roof sprinklers and other such preparations can also reduce the threat of fire damage.

Fire losses often include other structures such as sheds and barns, not to mention domestic animals. Other facilities are also affected, such as high tension power lines that can short out during a fire and other utilities and facilities located in the hazard zones.

The loss of life is higher in structural fires than in wildfires due to the warning time usually available in the latter. Occasionally, homeowners are injured or killed when they do not evacuate their homes (they can not be forced to leave) but most often civilian deaths are due to either people being trapped without warning or else an arsonist who cannot escape the fire he sets. Unfortunately, the largest number of deaths and injuries occurs to the firefighters themselves. Fires are notoriously unpredictable and occasionally they make sudden shifts that can trap even experienced firemen, as happened to 12 men in the Loop Fire near Los Angeles in 1966. The lives of professional firefighters are also lost in air and ground accidents while fighting the fires. This unfortunate loss of dedicated men is often due to the carelessness of others.

SECONDARY EFFECTS

The removal of vegetation by fire leaves the soil bare and open for erosion when the rains begin in the fall and winter. The fire kills the surface cover of vegetation, allowing the raindrops to hit the surface with

undiminished impact, splashing particles of soil loose which move downhill and is picked up by running water. The fire also destroys most of the roots that hold the soil in place, allowing running water to wash the soil away. Mudslides and mudflows are the results of these processes. Within the chaparral community another process increases the mudflow hazard. Under a chaparral cover, certain organic chemicals and compounds accumulate in the soil, making the soil non-wetable and impermeable to water. This produces what is referred to as a hydrophobic soil:

If a slope is burned over by a fire of intense heat, the near surface zone is purged of hydrophobic compounds. The vaporized compounds condense in a cooler zone just below the surface. Rainfall could then penetrate the surface layer and reduce its shear strength. Any excess water would migrate downslope, just above the impervious layer, carrying away the weakened material as a mudflow. (California Geology, June, 1973, p. 134)

This hydrophobic effect helps account for the much higher mudflows from burned chaparral slopes. In January, 1969, following the 20,000-acre canyon fire of August, 1968, mudslides washed downslope into the City of Glendora, destroying homes and other property valued at some 8 million dollars. Many more millions of dollars of damage were caused by mudflows in Big Sur in 1972, following the Molera Fire.

The buildings that are destroyed by fires are usually eligible for re-assessment which reduces income to local governments from property taxes.

Public utilities are strained by fires, water supplies depleted, power lines are downed and telephone systems disrupted. Flood control facilities may be severely taxed by the increased flow from the denuded hillsides and the resulting debris that washes down. Recreation areas that have been affected must also be forced to close or operate at a reduced scale.

The fires themselves last at most, only a few days, but their effects can last much longer. If a grassland area has been burned it will resprout the following spring, a chaparral community, however, takes three to five years. An Oak Woodland which has had most of the seedlings and saplings destroyed by fire, will require at least five to ten years for a new crop to start. Most susceptible to long term damage are coniferous timber stands, which will take fifty to a hundred years for such a forest to re-establish itself.

ILLUSTRATION 14.1
1952 to 1973 Fires Over 1,000 Acres
 Ventura County Fire Protection District

Name	Date Start	Structure Loss	No. of Structures	Areas Affected In County
Warring Canyon	9/14/52	\$ --	--	2,153
Ventu Park	11/7/55	55,285	8	13,840
Red Mountain	/55	--	--	1,200
Sexton Canyon	12/26/56	--	--	2,500
Little Sycamore	12/57/56	5,425	5	1,617
Lake Sherwood	12/28/56	135,560	20	7,747
Conejo Grade	6/18/57	--	--	1,000
Santa Susana Pass	7/3/57	--	--	1,482
Boulder Creek	8/27/57	500	2	3,987
Calumet Canyon	10/21/58	15,355	5	17,000
Broome Ranch	11/26/59	--	--	1,350
Doncon & Fletcher	1/15/61	--	--	2,700
Culbert Lease	12/4/62	9,600	4	5,525
Warring Canyon	8/28/67	27,000	1	3,808
Sence Ranch	10/15/67	236,786	16	17,431
Ditch Road	10/16/67	27,748	13	1,120
Parker Ranch	10/16/67	323,790	48	25,000
Timber Canyon	10/16/67	6,650	8	11,448
Torrey Canyon	11/20/69	--	--	1,800
Ventura City Foothill	9/25/70	61,565	12	5,241
Mayo Brush	9/26/70	119,900	3	4,390
				7,290 Total
Goodenough Road	10/5/71	--	--	2,100
Potrero	9/26/73	1,650	3	12,214
Sence Ranch	9/26/73	--	--	1,008

GENERAL INVENTORY OF THE HAZARD

LOCATION OF THE HAZARD

The hillside portions of the county are the main areas affected by the "Fire Hazard" (see Hazard Plate VIII). Generally, agricultural areas lie outside the hazard zones, since their potential for fire damage is low, therefore, discussion of the entire Oxnard Plain in this regard is minimal. Due to its hilly nature, most of the north half of the county has been included within the high fire hazard zone, except for the inhabited valleys and certain meadow areas and desert scrub areas in the northwest. The urbanized areas of the county represent another type of fire hazard area, whose characteristics differ markedly from wildland fire hazard areas.

HISTORY OF THE HAZARD

Fires have burned through various areas of the county virtually every year for which records are available, and probably for centuries before that. The largest fire in the county and the state's history burned 219,000 acres, mainly in the Sespe and Matilija Canyon of Los Padres National Forest in 1932.

Twenty-four fires of over a thousand acres in size have burned in the county since 1952. The largest and most destructive of these was the Parker Ranch fire of 1967 which burned from Chatsworth to Thousand Oaks, consuming over 25,000 acres. This fire destroyed forty-eight structures with a value of \$323,790. More recently, in 1973, the Potrero Fire burned through the entire Point Mugu State Park destroying more than 12,000 acres of chaparral and oak woodlands and forcing the park to severely restrict activities. This fire, like many others, was caused by man's carelessness.

DEFINITION OF THE HAZARD ZONE

The California Division of Forestry has devised a "Fire Hazard Severity Classification for California's Wildlands". This classification identifies fuel loading (the quantity of flammable vegetation and other fuel per unit of land area), fire weather, and slope as the primary criteria for classifying fire hazard in varying degrees of severity. This classification was developed to provide "local government and land use planners with a practical and logical system for classifying and delineating areas of varying severity of fire hazard". (Fire Hazard Classification, p. 1)

U. S. Geological Survey (USGS) topographic maps have been used as a basic tool in defining a series of classes for each of the three criteria. Fuel loading includes three classes (on Illustration 2). Light fuels occupy the uncolored areas on the USGS maps, outside of agricultural, urban or watercourse areas, and represents flammable grasses and annual herbs. Medium fuels are shown as "scrub" on the USGS maps and include brush and other perennial shrubs less than six feet in height and having a crown density of 20 percent or more. Heavy fuels are shown as "woods-brushwoods" on the USGS maps and include heaview brush species, woodland types and timber types over six feet in height and having a crown density of 20 percent or more (Fire Hazard Classification, p. 7).

In the Fire Weather Classification there are three classes related to the frequency of critical weather days occurring in each of the state's Fire Danger Rating Areas over a ten-year period (Illustration 14.2). The entire County of Ventura falls in the extreme class (Class III) with an annual average of more than 9.5 critical fire weather days (Fire Hazard Classification, p. 15).

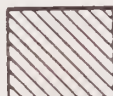
There are also three slope classes (Illustration 14.2) derived from California's Interagency Wildland Fire Danger Rating System. Slope is recognized by that system as having an effect on fire behavior similar to the effect of wind, i.e., an increase in slope produces an increase in the rate of fire spread. In analyzing the county, there were only two small areas of over 60% slope, which were grass covered and they were included in the extreme area.

ILLUSTRATION 14.2
Fire Hazard Severity Scale for Delineation
of California's Wildlands

CRITICAL FIRE WEATHER FREQUENCY	I			II			III		
FUEL LOADING	SLOPE %			SLOPE %			SLOPE %		
	0-40	41-60	61+	0-40	41-60	61+	0-40	41-60	61+
Light (Grass)									
Medium (Scrub)									
Heavy (Woods-Brushwood)									



MODERATE



HIGH HAZARD



EXTREME HAZARD

As indicated in Illustration 14.2, there are only two levels of severity for Ventura County - The Moderate and Extreme Fire Hazard Areas. These areas are delineated on Hazard Plate VIII.

NATURE OF THE INFORMATION

The hazard zones delineated on Hazard Plate VIII are derived strictly from the criteria of the State Division of Forestry. This system relies a great deal on the cartography of the USGS. However, no vegetation map that has been completed for the county has had more detail than the USGS Quadrangles (at a scale of 1:24,000 [1 inch = 2,000 feet]).

The agricultural and urban areas of the county cannot be considered wildlands for purposes of this classification. Isolated watercourses contain vegetation that is moist year round and, therefore, has a lower fire hazard. These areas are only included if they are near wildland areas or contain large amounts of vegetation that is seasonally dry.

The vegetation information will be updated during the 1974-75 fiscal year by the Ventura County Planning Department and the U. S. Forest Service. The fire hazard zones will be revised to meet Federal Firescape criteria when it is formally adopted.

GENERAL MANAGEMENT RESPONSIBILITY

INVESTIGATION

The Ventura County Fire Department constantly monitors the fire hazard in the county. They have ongoing programs for investigation and alleviation of hazardous situations.

The Ventura County Planning Department, in cooperation with the County Fire Department and the U. S. Forest Service, will do a vegetation map of the county to help in the further determination of fuel loading characteristics. This hazard element will be updated as necessary.

PEAK LOAD WATER SUPPLY REQUIREMENTS

The water supply for any structure is determined by a complicated formula in the "water works" ordinance. This ordinance was written and is enforced by the County Department of Public Works and City Public Works Departments. It requires a minimum fire flow of 500 gallons per minute (GPM)

in residential areas, 1,000 GPM minimum in commercial areas, and 1,500 GPM minimum in industrial areas. The peak demand rate is the peak domestic flow or the fire flow plus $\frac{1}{2}$ the peak domestic load whichever is greatest. These flows are minimum requirements only and greater flows may be required by the Fire Chief.

MINIMUM ROAD WIDTHS

The entire county has the same road width requirements except for Thousand Oaks, whose minimum is slightly larger. All are adequate to allow fire access. Thirty-two feet is the minimum width for a cul-de-sac or loop road. A cul-de-sac must have a minimum radius of 40 feet. Thirty-six feet is the minimum road width for a residential minor road. All other roads have larger minimum widths.

CLEARANCES AROUND STRUCTURES

The best way to protect a structure, in the hazard zone, is to clear all flammable concentrations of brush from around the structure. Otherwise, this brush can provide an avenue for the fire to approach the building. Well maintained ornamental plantings do not burn readily although there is no plant that will not burn under the right conditions. To reduce the fire hazard, four steps can be taken. (Landscape, p. 1)

1. Increase effectiveness of plantings with a high pressure sprinkler system.
2. Keep landscape clean. Remove litter under trees and shrubs; prune out deadwood. Remove dead and dried portions of ground covers and succulents.
3. Leave space between remaining shrubs and trees to help prevent fire spread.
4. Plant lawns, succulent ground covers, or other low growing plants around all structures, and water regularly. Do not allow continuous tree or brush canopy next to buildings. (Landscape, p.1)

If plantings cannot be used, a minimum clearance of brush is necessary to protect the building from the spread of fire. A minimum clearance of 30 feet is required around all structures, increasing to 60 feet clearance in high grass and low brush areas and up to a 100-foot minimum in any high brush area. If the property owner does not clear his land it will be done by county crews and the owner billed for the expense. These clearances do not apply to ornamental trees and shrubs or ground cover less than 18

inches high "provided they do not provide a means of rapidly transmitting fire from the native growth to any structure". (Uniform Fire Code, 1973, p. 257, Art. 16a2, Appendix E)

Orchards provide a good fuel break in most cases - if the trees are maintained. For example, a belt of orchards already protects much of Santa Paula. Eucalyptus trees are also used for wind breaks; however, they must be kept very well trimmed or they can transmit a fire down their entire length circumventing any fire break provided by an orchard or field.

FUEL MANAGEMENT

Many forms of fuel management have been employed as a means of fire control, including firebreaks, fuel breaks, vegetation conversion and controlled burning.

Fire breaks are probably the most common and have been used the longest. They consist of clearing an area from 50 to 200 or more feet wide (of all flammable material) usually along a ridge top. Unfortunately, these fire breaks tend to be highly susceptible to erosion and are aesthetically not very pleasing.

Fuel breaks are much larger, 200 to 600 feet wide where all but scattered plants and grasses have been removed. These breaks have been effective in stopping wildlife and have a parklike appearance. However, they take more maintenance than a fire break, which can be cleared by quickly bulldozing over it. (Also, the herbicides often used to construct fuel breaks have created much controversy.) A proposed alternative introducing plants for fuel breaks, has not proven effective, as yet. Such vegetation conversion requires the removal of the natural vegetation and the replacement with other less flammable ones. The expense is high for this type of management program and as yet no acceptable plant has been able to compete with the native chaparral species in an unmanaged environment.

Controlled burning is a process by which the highest hazard areas are burned during the safest times of year, with the conditions as much as possible controlled before the fire is started. The biggest problem is that once a fire is lighted it is never truly "under control" since it can only be stopped at certain boundaries. If conditions change suddenly these boundaries can be breeched. Also, the Air Pollution Control District restricts controlled burning to certain days when the weather conditions are correct; these days are not always the safest in terms of fire control.

However, all things being considered, controlled burning seems to be the best fuel management method presently available. Controlled burning for range improvement and fire protection has gone on for centuries. Ranchers in California working with Division of Forestry and University of California Research and Extension Services have developed quite involved controlled burn procedures. In Ventura County, these private controlled burns are under the supervision of the supervision of the County Fire Department and are encouraged by them.

The U. S. Forest Service is instituting a controlled burn program in the Los Padres National Forest this fall and plans to continue it as an ongoing conflagration prevention, fuel management tool. The Ventura County Fire Department also encourages controlled burns and they have used them to protect communities such as Santa Paula.

WARNING AND EVACUATION

In the case of a major wildfire, owners of homes and inhabitants of communities, in the path of the flames, are warned of the threat and evacuation is recommended if the threat is eminent. The responsibility for warning and evacuation is in the hands of the law enforcement agencies, primarily the Sheriff's Department, since most fire hazards exist on unincorporated county territory. Evacuation can only be recommended, not ordered, since no one can force a person to leave his house. Formal evacuation routes are not predetermined, due to the unpredictability of a fire. Thus, law enforcement agencies react accordingly to a given situation.

SUPPRESSION

Outside of the boundaries of Santa Paula, Fillmore, Oxnard, San Buenaventura, and the Los Padres National Forest, the Ventura County Fire Department has responsibility for wildland fire suppression on all private land. Normally much of this area would be the responsibility of the California Division of Forestry but the county has contracted with the state to assume this task, in return for payment by the state. The county has mutual aid and automatic aid agreements with the four city fire departments and the surrounding counties and cities. These mutual aid agreements obligate the departments to help each other in case of a major fire, if requested. Automatic aid agreements obligate the nearest fire company to respond to a fire regardless of the jurisdiction. The State Office of Emergency Service can be called upon for further aid, if necessary, as can Federal agencies, including the Department of Agriculture, Interior, and in extreme cases, Defense. Private companies and individuals have also assisted,

upon request, during major fires.

Ventura County is lucky to have an outstanding Fire Department with an excellent well-deserved reputation. They have good equipment in most areas, the major exception being their lack of an up-to-date air capability. To compensate for this lack, they have access to air tankers from the state and by mutual aid agreements from the U. S. Forest Service. However, other fire fighting agencies such as Los Angeles County and the California Division of Forestry have found that their response capability is much improved with the use of large modern helicopters such as those that were developed for the Viet Nam War. These "Hueys", or their civilian counterpart the Bell 204-B, can carry 350 gallons of water, a fire retardant, or an eight man fire crew. These helicopters can be used for ferrying crews to remote fires for early suppression or for dropping retardant or water on small blazes to keep them from spreading. Fire Bosses on major fires have found them to have important advantages over the air tankers. With portable mixing equipment, which can be moved right to the fire line, "helitankers" can deliver retardant to the fire with a round trip time of 3 to 5 minutes. Helicopters have an edge over air tankers in terms of total gallons of retardant delivered, accuracy of drop and costs per gallon of retardant delivered. The larger aircraft has other advantages so that the two complement each other. (California Aflame, p. 50) The larger aircraft can provide larger volume per drop and greater speed and range. At the present time, the County Fire Department is scheduled to acquire a helicopter in 1977, according to its 1975-1985 Plans and Programs budget.

AFTER THE FIRE

Numerous relief agencies, such as the Red Cross, become involved in case of a major fire. They provide disaster relief to the victims and provide medical aid and assistance to the fire fighters. In case of a major disaster, state and even federal relief is possible, including low interest loans to individuals and local governments.

The reseeding of private land after a fire is the responsibility of the California Division of Forestry. After a fire they send in range and soil specialists to determine if emergency revegetation is necessary to prevent mudslides. In the past, the Ventura County Flood Control District has cooperated in some reseeding projects.

LAND USE DECISIONS

The Board of Supervisors and the City Councils and the various Planning Commissions have authority over land use decisions in fire hazard areas. Fairly simple design criteria can be used to make hillside developments relatively safe from fire. There are also fuel management methods that can be used to reduce the fire hazard to hillside developments.

Fuel break design criteria is available for the initial clearing program. The maintenance of these areas in a fire safe condition along with increasing vulnerability to erosion and slide problems presents a continual high maintenance expense that must be borne. Structural encroachments upon hillsides generates a number of problems:

1. Increases direct cost in maintenance of public services and amenities.
2. Increases fire risk in the adjoining highly inflammable brush areas. (Children playing with matches, etc.)
3. A reduction in the capability of fire suppression forces to accomplish their mission.
 - a. Initial attack time is extended due to road grades and curves.
 - b. Fire spread rate and intensity is increased due to slope factor.
 - c. A potential net loss of strategic locations to fight a fire from.
 - d. A built-in dilution potential of available suppression forces. (Forces are diverted to protect individual structures rather than concentrate on the key fire locations.)
 - e. A potential loss of suitable strategic locations to construct fuel breaks, green-belts or other fire prevention measures to protect from fires burning into or out of communities and the adjoining wildlands.

Structural development on slopes where the above factors cannot be internally mitigated are not in the public interest and should be discouraged.

LOCAL DISCUSSION

LOCAL INVENTORY OF THE HAZARD

The hazard zone extends into all areas where native brush can be found growing in pure natural stands. This is most common on undeveloped hillside areas. The moderate hazard zone encompasses areas of grass and low brush, in areas of low to moderate slope. The extreme hazard zone includes all areas of high brush and woodland, and all steep slopes regardless of vegetation. (Hazard, Plate VIII)

Within the hazard zone, there are certain areas of the county that have been identified as particularly hazardous by the County Fire Department.

1. The Yerba Buena Road-Carlisle Canyon Area. This area is a major hazard zone, especially because houses are isolated in large areas of brush and access is poor. Although much of this area burned (partially) as recently as 1955 and 1956, some of it has not burned at least since around the turn of the century when records first were kept. The fire potential as a result, is quite high.
2. The Lake Sherwood Area. This area, which had a serious fire in 1956 that destroyed 20 structures and burned over 7,000 acres, is particularly susceptible to another conflagration of the same type. Here there are numerous individual homes interspersed with brush areas. The roads are narrow and often in poor repair and there are only limited evacuation routes. Another fire with serious potential was started in 1973 in this area but was controlled before it entered the heavily built-up areas.
3. Westlake Area. Another particularly hazardous situation in the same area exists within the City of Thousand Oaks in parts of Westlake where the houses are being built on ridges into the brush area. This situation is very reminiscent of the conditions that existed just before the disastrous Bel Air Fire of 1961, in which over 500 structures were destroyed.
4. Sulphur Mountain. Last burned in 1929, this area has had a tremendous build-up of fuel since then. There are widely scattered residences on the mountain interspersed with heavy brush areas. The access to the area is poor with very limited evacuation routes.

5. The Matilija Canyon Area. This area has been identified by both the U. S. Forest Service and the Ventura County Fire Department as a particularly hazardous area. The canyon consistently receives the highest precipitation in the county, which is reflected in a heavier, more lush vegetation. This area was burned extensively in 1917 and partially in 1932. Much of the vegetation has had fifty years of exceptional conditions to develop in. Here again the access is poor with buildings scattered amongst the natural vegetation.

Although only the above areas have been especially identified by the County Fire Department, any area of high brush that has not burned in the last twenty years is equally hazardous. Also hazardous is any area that has scattered dwellings, interspersed with brush with restricted access or limited evacuation routes. Wherever man interacts with the natural vegetation, a threat exists to both.

LOCAL RESOURCES AFFECTED BY THE HAZARD

Although the various Edison Company transmission lines and a transmission substation are the only vital services immediately vulnerable within the hazard zone, there are also some communities that could be threatened. Fortunately, most facilities constructed within the hazard zone are built and landscaped in such a way that the damage from fire is greatly reduced. For example, Moorpark College, built in an isolated area, is surrounded by parking lots on the hazardous sides and is carefully landscaped and well tended which makes it very fire resistant.

On the coast, the communities of La Conchita, Seacliff and Solromar (on the south coast) abut the high hazard zone. Most of the other coastal communities are separated from the hazard zones by the coast highway, an effective firebreak under most conditions. The communities on the Ventura River including Oak View and Meiners Oaks also are interspersed with, or are adjacent to hazard zones as is Moorpark and Piru. Oil production and storage facilities are located in the hazard zones but are usually well protected. However, as oil production declines, and if less maintenance is accomplished by the oil companies, the threat to the facilities could grow more severe.

FINDINGS

PROBABILITY OF OCCURRENCE

Fires erupt every year in Ventura County. The areas that have high brush and that have not been burned for quite some time are probably the most susceptible. Most areas of high hazard have burned at least once within the last fifty years. Therefore, these areas could be expected to burn again in the next fifty years unless some method of fuel management is undertaken.

SEVERITY OF THE HAZARD

The effects of a wildfire on an area depends a great deal upon preventive measures and recovery actions following the fire.

The various fire agencies will make every possible effort to save structures during a fire but their effectiveness depends upon the preventive measures taken before the fire. If the brush has been cleared, a fire resistant roof installed, a sufficient supply of water is available and access is provided for the fire equipment, then there is an excellent chance to avert major damage. The chances decrease proportionately if any of these precautions are not taken.

After a fire, efforts must be made to reduce the risk from mudslides. This could include reseeding areas by the State Division of Forestry, the Ventura County Flood Control District, or the individual homeowners. Even if reseeding has been undertaken, precautionary measures should be taken to protect communities or individual structures from mudslides. The Ventura County Flood Control District distributes a Homeowners' Guide for Debris and Erosion Control in case of a mudslide threat.

RESOURCES AFFECTED

Those communities located adjacent to the hazard areas could be affected but there are few critical facilities located in the hazard zone that are not adequately protected. There are, however, some particularly hazardous lightly populated locations, that could be severely damaged in case of a major fire.

Due to distance from County fire stations, there may be considerable response time lag for structural fire protection on private lands within the National Forest boundaries. Zoning ordinances and building codes should be directed toward making structures inherently firesafe in these areas.

NATURE OF THE INFORMATION

Although the data regarding the hazard zones is somewhat generalized and was compiled from older sources, it is adequate for planning purposes, since the vegetation zones themselves change very little in the long run, unless affected by man. Admittedly, mapped vegetation zones are basically approximations, detailed analysis could make them even more precise.

OTHER FINDINGS

The hazard of major fires will continue in the county as long as man interacts with the natural vegetation. The hazard can be reduced by an effective ongoing fuel management program. It is more reasonable to expend the funds to control hazardous areas before a conflagration occurs than to expend larger sums to fight the inevitable fire, with the resulting threat to life and property.

The County Fire Department will need continued support in terms of replacement of equipment and expansion of services and capacity if it is to maintain its present high standards and to meet the needs of the county's growing population. Illustration 14.3 indicates the Department's projected needs over the next ten years.

ILLUSTRATION 14.3

VENTURA COUNTY FIRE DEPARTMENT PLANS AND PROGRAMS 1973-1983

YEAR		NEW STA.	STAFF	FLSA	AERIAL	RELI CREW	COMST MAINT.	FIRE TRX REPL.	FIRE TRX NEW	AERIAL TRX.	RELIC.	DOZER REPL.	NO. OF FIRM.	ASSESSED VALUATION	POPULATION	NO. OF STA.	A.V. PER FIRM.	FIRM. PER POP.	A.V. PER STA.	POP PER STA.
1975	21(R) 31(R) Trn.		1 Capt 1 Engr					3				1	297	793,000,000	279,970	26	2,670,000	942	30,500,000	10,768
1976	45(A) 24(R) Trn.		1 D.C. 1 B.C.	16	9		10	3		1		1	334	831,400,000	292,970	26	2,489,000	877	31,900,000	11,268
1977	Hdq(R) S. Rsa 41(A)	12	2 B.C.	16		9	10	3	1		1	1	383							
1978	54(A) Oak Prk.	12	1 F.P.	16			10	3	1			1	422	869,800,000	318,970	28	2,061,000	755	31,064,286	11,391
1979	OAFB 56(R)	12			9		10	3	1	1			453							
1980	Somis 46(A)	12	1 F.P.				10	2	1				476	908,200,000	344,154	30	1,908,000	723	30,270,000	11,471
1981	25(A)		1 Trn			9		1			1		486							
1982	Sunset	12						3	1				498	946,600,000	380,154	31	1,901,000	763	30,500,000	12,263
1983	53(A)				9			1		1			507							
1984	Hpk. Col.	12						2	1				519	985,000,000	416,000	32	1,898,000	801	30,780,000	13,000
1985	Bell Cyn	12						1	1				531							
PERSONNEL								APPARATUS & EQUIPMENT					PROTECTION RATIOS FIREMAN TO POPULATION AND ASSESSED VALUE							
A-Alteration B-Relocate																				

PROJECTED NEEDS BEYOND 1985, OR POSSIBLY PRIOR DATE IF GROWTH REQUIRES

1. Long Ranch
2. Erringer Road
3. Tape Canyon
4. Station 53 (A)
5. North Camarillo

11. In new developments either shake roofs should be prohibited or else they should be interspersed with fire resistant roofs to inhibit the spread of fire from roof to roof.
12. Regulations for clearance around oil production facilities should be strictly enforced especially in fields that are slowly shutting down.

Organization

13. Study the feasibility of merging the City Fire Departments with the County Department to increase efficiency and lower costs.
14. Study the feasibility of strengthening the aerial response capability of the Fire Department by equipping it with large capacity helicopters.

Data Base

15. A detailed vegetation map should be compiled to increase the accuracy of the fire hazard zones for use in future regulatory fuel management activities.

STRUCTURAL DEFICIENCIES

If a builder build a house
for a man and do not make
its construction fair and the
house which he has built
collapses and causes the
death of the owner of the
house, that builder shall be
put to death.

Code of Hammurabi,
2130-2088 B.C.



Illustration 15.1

Ruins of San Francisco City Hall, 1906. Cornerstone laid February 22, 1872. Dedication July 1, 1899.

Source: Seismic Study, West Wing California State Capital, June, 1972.

GENERAL DISCUSSION

GENERAL DESCRIPTION

Simply stated, the greatest single cause of life-loss and property damage in an earthquake is the effect the shock has upon man-made structures, i.e. shattered glass, falling bricks and other materials, building collapses, etc. A major cause of such damage has been the design and construction of structures which have been unable to resist the strong lateral forces created by earthquakes. At this time, however, there is sufficient knowledge to construct structures which can withstand fairly high lateral forces. Realizing this, it appears that seismic safety can be achieved through careful development and construction practices.

This section on structural deficiencies focuses on 1) the evaluation and identification of hazardous structural deficiencies and 2) the development of land use and construction standards to minimize any hazard created. The subject will be treated generally since local inventories of the hazard are not available and such research is beyond the capability of this report.

In discussing structural deficiencies an understanding of the types of structures and their response to earthquakes is essential. Illustrations 15.2 and 15.3 are a summary of building types and their response to seismic forces and provides an initial indication of where seismic hazards may exist. Briefly, unreinforced masonry, brick and concrete buildings are very susceptible to damage in earthquakes. Parapets, chimneys and other appendages are also hazardous, when not properly attached or reinforced. Another indication of a hazard is the year when a structure was built, since seismic safety standards in buildings were not required or generally used until 1933, after the Long Beach earthquake. Upgradings of the building code have occurred periodically since then.

The problem of seismic structural safety is two-fold, involving 1) the prevention of the hazard, and 2) the abatement of hazards already existing in buildings. This requires responsibility in 1) the formulation of engineering standards and the enforcement of the standards and 2) the identification and abatement of the hazard in existing structures.

Obviously, the potential severity of the earthquake hazard increases as density of settlement increases, as unsafe structures continue to be used, and as new seismically inadequate structures are built. A graphic illustration of the possible effects of structural deficiencies

Illustration 15.2 Seismic Responses of Building Types
Source: Tri-Cities Safety Study, Pg. 74-75

TYPES OF BUILDINGS AND PAST PERFORMANCE

Steel Frame Buildings During the 1971 San Fernando earthquake, no significant structural damage was experienced by any completed earthquake resistive steel-frame buildings in the Los Angeles area. Many did suffer other kinds of damage resulting in a maximum loss, in one case, of \$200,000, or about 1% of the value of the building.

Older steel frame non-earthquake resistive buildings performed much more poorly. While none sustained structural damage, many experienced non-structural losses amounting to over 5% of assessed market value and in one case over 25% of assessed market value.

Concrete Frame Buildings The experience of the 1971 San Fernando quake showed that earthquake-resistive concrete frame buildings performed generally as well as steel frame buildings when located 15 to 25 miles from the epicenter. Of the high-rise buildings which suffered the highest amounts of damage, however, many more were of reinforced concrete than steel.

Unreinforced Concrete Block and Hollow Clay Tile Buildings Older buildings of non-reinforced concrete block laid in sand-lime mortar are extremely vulnerable to earthquake damage. Many of this kind of building suffered slight and moderate damage in San Fernando, and a few experienced severe damage.

Brick Buildings and Reinforced Brick Buildings Brick and reinforced brick buildings also do very poorly in earthquakes. In the San Fernando quake, pre-1940 brick structures suffered much more severe and moderate damage than any other type.

Reinforced Masonry Buildings Most of these buildings were built under modern building codes and can be considered generally safe. Their weakness in San Fernando was joint failure, leading occasionally to detachment of roof from walls.

Steel and Sheet Metal Buildings Metal-sided buildings, usually used for storage and factories, perform very well in earthquakes because of their light weight and flexibility.

Wood-Frame Buildings Wood-frame structures have the best earthquake performance record of all older and smaller buildings. Their light mass accounts for much of their low susceptibility to damage.

BUILDING COMPONENTS AND PAST PERFORMANCE

Parapets and Chimneys Probably the greatest loss of life from earthquakes has resulted from the failure of unreinforced unit masonry, particularly unreinforced brick parapets on commercial buildings. Persons on the streets or inside buildings are often injured by such falling masonry. Chimneys can also be a great hazard in houses and small apartments.

Signs and Appendages Signs, marquees, canopies and general ornamentation extending out from buildings pose a great potential hazard in earthquakes if not adequately anchored to the building.

Facades Two kinds of hazards can be caused by building facades. Masonry veneer facades inadequately anchored, can be shaken loose by an earthquake, causing danger similar to parapets. On the other hand, open glass facades as on stores, can cause amplified twisting to the building and shattering of glass on the sidewalk.

Ceilings and Hanging Items Plaster ceilings and ceiling tiles are often shaken loose during an earthquake, as are poorly-anchored hanging fixtures, resulting in human injury.

Building Contents Heavy furniture, appliances, bookcases, machinery, etc. often are thrown about during earthquake shaking and can cause damage and injury.

Access Routes Stairwells and doorways are often blocked after earthquakes. Doors and elevators are often inoperative.

Illustration 15.3

HAZARD COMPARISON OF NON-EARTHQUAKE-RESISTIVE BUILDINGS

Note: This table is intended for buildings not containing earthquake bracing, and in general, is applicable to most older construction. Unfavorable foundation conditions and/or dangerous roof tanks can increase the earthquake hazard greatly.

SOURCE: Steinbrugge, Karl V., Earthquake Hazard in the San Francisco Bay Area.

Simplified Description of Structural Type	Relative Damageability (in order of increasing susceptibility to damage)
Small wood-frame structures, i.e., dwellings not over 3,000 sq. ft. and not over 3 stories.	1
Single or multistory steel-frame buildings with concrete exterior walls, concrete floors, and con- crete roof. Moderate wall openings	1.5
Single or multistory reinforced- concrete buildings with concrete exterior walls, concrete floors, and concrete roof. Moderate wall openings.	2
Large area wood-frame buildings and other wood-frame buildings.	3 or 4
Single or multistory steel-frame buildings with unreinforced mason- ry exterior wall panels; concrete floors and concrete roof.	4
Single or multistory reinforced- concrete frame buildings with un- reinforced masonry exterior wall panels, concrete floors and con- crete roof.	5
Reinforced Concrete bearing walls with supported floors and roof of any materials (usually wood).	5
Buildings with unreinforced brick masonry having sand-lime mortar; and with supported floors and roof of any materials (usually wood)	7 up
Bearing walls of unreinforced adobe, unreinforced hollow con- crete block, or unreinforced hollow clay tile	Collapse hazards in moderate shocks XV-5

took place in Agadir, Morocco. In 1960 an earthquake calculated at a Richter magnitude between 5.5 and 6.0 shook Agadir's 33,000 inhabitants. After it was over 12,000 persons had been killed and 12,000 were injured from structural failures. Reviewing the structures in Agadir:

The most prevalent construction material was older masonry which varied from stone (with mortar of mud and sand) to more modern construction of stone or clay tile with mortar ranging from weak mud and sand to good quality sand cement. None of the masonry was reinforced. The second most prevalent type of construction was usually a very poor quality reinforced concrete which had not been designed to resist earthquake forces. (Department of Commerce, NOAA, 1972, Part B, pg. 9)

In magnitude this earthquake compares to the Point Mugu quake of February 21, 1973, which measured 5.7 on the Richter scale. This moderate shock caused minor damage in the Point Mugu-Oxnard area. One of the main differences being that our construction standards were much better than those in the Morocco experience.

A more relevant experience is the 1971 San Fernando earthquake. Calculated at a Richter magnitude of 6.6, it was a moderate shock near a highly developed area and has since been considered a test of the modern city's ability to undergo seismic shock. The number of deaths totaled 58 which were directly attributed to earthquake effects, a number thought to be low due to a combination of fortunate circumstances. From a Report of the Los Angeles County Earthquake Commission, it is worth repeating the following scenario which makes one aware of the possibilities of a catastrophe in our own area.

Had the earthquake centered twenty miles farther south close to the center of population in metropolitan Los Angeles, it would have done much more damage and caused the collapse of many more old buildings. Had it occurred three hours later, there would have been many more occupants in the buildings that did collapse. Had the freeways been crowded, the bridges that collapsed would have caused many more deaths and injuries, and other casualties would have resulted from automobile accidents caused by the sudden disruption of the thoroughfare. Had the earthquake occurred when more people were on downtown streets there would have been many more casualties from falling debris. Finally, the lower San Fernando Dam had only four feet of freeboard after its partial failure; had

it failed completely - or even after emptying was well along an area inhabited by 80,000 people would have been inundated.

The 1971 earthquake pointed out major structural deficiencies in the ability of old and new buildings to undergo seismic stress. The San Fernando Veteran's Administration Hospital had a number of buildings built between 1925 and 1927 without earthquake resistance measures which were severely damaged. Forty-six persons died in the collapse of two such buildings constructed of reinforced concrete frame. The main Olive View Medical Center buildings, recently completed, were constructed of reinforced concrete under earthquake resistant standards. It suffered extensive damage including the collapse of the Psychiatric building, causing the deaths of three persons.

The cause of structural deficiencies may be any one or combination of factors. Construction practices, policies on land use, enforcement of building codes and rehabilitation programs have not always considered the consequences of seismic activity.

Building Codes are the basis for establishing criteria to meet seismic safety standards. The goal of seismic safety was aptly expressed by the structural Engineers Association in their publication, "Recommended Lateral Force Requirement and Commentary, 1963," when discussing the purpose of the seismically oriented building codes. The intent is to construct structures which will:

1. Resist minor earthquakes without damage.
2. Resist moderate earthquakes without structural damage, but with some non-structural damage.
3. Resist major earthquakes of the intensity of severity of the strongest experienced in California, without collapse, but with some structural as well as non-structural damage.

If one considers these intents as valid, then it is quite obvious that these standards have not been met in past earthquakes.

GENERAL EFFECTS OF THE HAZARD

PRIMARY EFFECTS

The primary effects of the hazard is the loss of life and property. During an earthquake, structures can be expected to undergo the forces of fault displacement of ground-shaking. If a structure is built over faults which rupture, it will inevitably be severely damaged. However,

the area affected is localized over the fault. On the other hand, ground-shaking effects normally extend over many square miles and structures can be built to resist such forces.

The amount of damage sustained by any particular structure is largely dependent on its condition and the intensity of the forces affecting it. "Ground motion is excited by the propagation of waves which emanate from the hypocenter (source) of an earthquake." (Department of Commerce, December, 1971, p. 31). Such waves generate a vibrational force whose accelerations determine the stress applied to a structure. Accelerations are measured by seismographs strategically located throughout the state. During the 1971 San Fernando earthquake, the largest motion ever recorded was located at the Paicoma Dam, the forces exceeded 1.25g and there was almost continuous accelerations ranging from 0.5g to 0.7g for 12 seconds. Previous thinking considered .5g to be a "practical maximum that could be transmitted by an earthquake." (Department of Commerce, December, 1971, p. 34).

With this type of acceleration, structures which have been reinforced to withstand seismic forces have proven to do much better than those not reinforced. This, of course, does not consider the effects on a structure of liquefaction, ground failure or subsidence which are considered in other sections.

The extent of damage covers all structures including buildings, utilities, gas, water and sewage lines, highway bridges and dams. In the 1971 San Fernando earthquake, it has been estimated that over \$500 million worth of damage occurred and 58 deaths were directly attributed to the earthquake, nearly all from structural failures. "It was reported that approximately 850 homes, 65 apartment buildings and 574 commercial-industrial buildings were so damaged that they were vacated, some 4,800 homes, 265 apartment buildings and 1,125 commercial-industrial buildings had appreciable damage, and about 30,000 structures had lesser damage." (L.A. County, 1971). Generally, structures that suffered the most major damage were older masonry buildings not reinforced against lateral forces. This included the Veterans Administration Hospital Buildings that collapsed and killed 46 persons.

Not all modern structures withstood the seismic forces. Collapse of the first floor of the 2-story Psychiatric Building and severe damage to other buildings at the recently completed Olive View Medical Center is evidence that building to the minimum code specifications without regard to the special design modifications is not enough. Other structural weaknesses appeared in connectors of roofs to masonry or tilt-up walls in commercial or industrial buildings, and inadequate reinforcements of some

concrete columns, leading to collapse of those buildings. (Department of Commerce, December, 1971, p. 369).

Another direct effect was the near collapse of the lower Van Norman Reservoir which could have inundated an area inhabited by 80,000 persons. The upper and lower Van Norman Reservoirs are old earthen dams constructed by the hydraulic-fill method in 1915 and 1919. The lower dam, built in 1915, nearly collapsed and is no longer in use. The upper dam built in 1919 settled about 3 feet and moved laterally about 5 feet at the crest, but did not collapse and is being used at reduced capacity. (Department of Commerce, December, 1971, p. 369).

The collapse of five new freeway overpasses disrupted transportation arteries. Public utilities were interrupted and underground water, gas and sewer lines were also damaged. The converter station at the Pacific Intertie of PG & E, completed in 1970 suffered \$30 million worth of damage. The General Telephone Company suffered \$4.5 million in damages and 10-20,000 customers lost service for a month. Gas pipelines broke because of ground deformation and 17,000 customers lost service from 4-12 days. In addition the water pipes ruptured in over 1,000 places and the lines were plugged with sand and debris put into the system from damages at the Lower San Fernando Dam. (Jennings, 1971).

SECONDARY EFFECTS

A major secondary effect resulting from the damage of structures is the disruption of transportation, communication and power systems. In times of disaster these systems are essential for mitigating disaster effects. Structures which house vital or critical facilities such as public buildings which coordinate and administer disaster services, fire stations and hospitals, should remain operational after an earthquake. The disruption of transportation arteries could increase the chance of accidents and prevent movement of emergency vehicles.

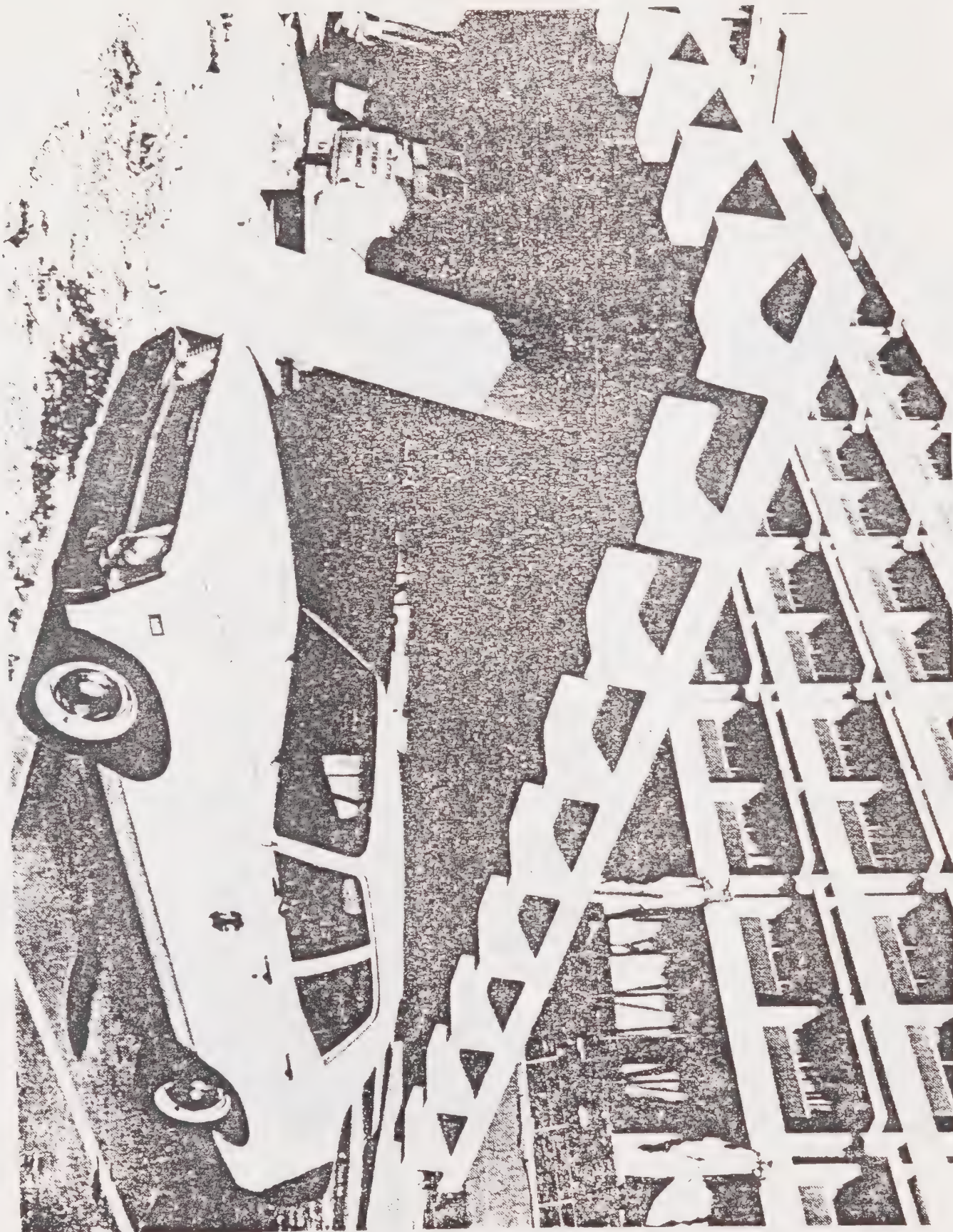
Another effect is the cost of rebuilding. Replacing a building is often more expensive than when it was originally built. Since reinforcement during ordinary construction projects only adds 1-2% to the cost it is not very practical to exclude sufficient reinforcements. (Joint Legislative Committee, 1974, p. 9). Both government and individuals are burdened with heavy replacement costs. Some things can never be replaced.

Illustration 15.4



Old building at Veterans Hospital had a skeleton concrete frame and unreinforced hollow tile filler walls. Newer parts of the hospital complex built under modern structural codes performed much better than the older sections.

SOURCE: R. IACOPI, Earthquake County



CRUSHED AMBULANCES

Olive View Hospital

SOURCE: California Earthquake, 1971, J.E.K. Publications

GENERAL INVENTORY OF THE HAZARD

LOCATION OF THE HAZARD

At the present time there is no comprehensive survey or information available on the location of structural deficiencies in the County of Ventura, and it is beyond the scope of this report to conduct this survey. Such an inventory would identify the seismic risk that presently exists, through survey and evaluation of public buildings, hospitals, schools, churches, industrial buildings, freeways, dams, utilities, etc. From this the need for the abatement of this risk can be evaluated and programs developed.

In a study of a small portion of Camarillo which was surveyed in a general manner by the Ventura County Building and Safety Department, the majority of the residences were discovered to be in some way "substandard" as would be defined in the housing code. Though "substandard" reflects many deficiencies and not necessarily seismic safety, nearly all of these structures were built before 1933. This could be considered a hazardous condition, because structures built before 1933 did not require reinforcement against seismic forces and past experience indicates they have generally done very poorly in earthquakes. This is especially true for masonry and concrete buildings, such as those found extensively in Ojai. Wood frame residences are generally much safer, but if they were built over 40 years ago and not kept in good condition a hazard could exist.

There are other concentrations of structures considered substandard and these areas warrant further study to evaluate existing levels of risk and the abatement of risk. Such areas which might warrant further study include: Saticoy, Nyeland Acres, El Rio, Moorpark, Box Canyon, and older parts of Ventura and Oxnard.

HISTORY OF THE HAZARD

The largest earthquake known to have affected Ventura County was centered near Fort Tejon in 1857. The damage was severe from a shock estimated around a magnitude of 8.0. It was reported that the roof of the Mission church at San Buenaventura collapsed, and six miles from the mouth of the Santa Clara River the bed of the river was severely cracked. The cracks were described as 6-8 inches across, which was probably due to lurching and there was indication of liquefaction in the saturated alluvium. (California Division of Mines and Geology, 1973, p. 40). Such severe ground-shaking in the same area today would undoubtedly cause severe damage.

Since that time no major earthquakes centered in the County have been recorded. The strongest recorded measuring a magnitude of 5.7 , minor damage was caused in Ventura by the Santa Barbara 1925 earthquake, an offshore shock in 1941. During the 1971 earthquake structural damage occurred in Simi Valley to older buildings, including a church.

Within the county a 4.7 shock was centered near Port Hueneme in 1957 and some minor structural damage occurred as a result. On February 21, 1973, an earthquake was centered near Point Mugu and measured on the Richter scale at 5.7. Brick chimneys and buildings in Oxnard were damaged, as were some bridges.

DEFINITION OF THE HAZARD ZONE

For this study no delineation of a hazard zone is possible within the scope of this study. Such a zone could only be developed after a survey identifying and classifying various structures that may create seismic hazard.

The following criteria could be considered as guidelines for determining whether a building is in need of inspection for structural deficiencies. These criteria were presented in the report of the Joint Committee on Seismic Safety to the State Legislature.

- 1) The building was constructed before 1933, or a later designated date. Later dates may be established for a specific local jurisdiction, based on an evaluation of each jurisdiction's history with respect to design standards and effectiveness of enforcement. This should probably be done by the proposed State Commission on seismic safety.
- 2) The building lies within a zone designated as probably subject to substantial earthquake shaking. To facilitate administering the hazards reduction program, the zone areas should conform to existing governmental boundaries, and avoid bisecting individual local jurisdictions.
- 3) The building is of a construction with "load-bearing-unreinforced masonry walls using lime and mortar, and wood floors and roof.

GENERAL MANAGEMENT RESPONSIBILITY

INVESTIGATION

Structural deficiencies has been and continues to be studied by the Structural Engineers Association of California, who have a state-wide Seismology Committee. This committee was first formed in 1957 to resolve differences in existing codes and prepare a single set of recommendations for lateral-force criteria. (Joint Legislative Committee, 1974, p. 198). These recommendations are updated regularly and represent the present state of knowledge regarding structural safety and are incorporated in the Uniform Building Code.

In 1969 the State Legislature formed the Joint Committee on Seismic Safety and has since conducted hearings and investigations of past disasters. They have developed current standards, policies and program proposals. Their final report was published in January, 1974. Information on structural characteristics of buildings throughout the County is presently being gathered by the County Planning Department.

WARNING AND ALLEVIATION

In 1970, the State Legislature adopted amendments to the Health and Safety Code that requires the State Commission of Housing and Community Development and the governing body of each city and county to in part adopt rules and regulations which are contained in the Uniform Building Codes, 1970, Uniform Plumbing Code, 1970, Uniform Mechanical Code, 1970 and the National Electrical Code, 1971. However, local entities have the ability to adopt these provisions as the situation warrants, and does not discourage development of stricter regulations.

The County Board of Supervisors and the respective city councils have the responsibility for the development and implementation of building standards and the alleviation in hazardous situations for nearly all structures. These policies are enforced by their Building and Safety Departments; or in the case of the cities of Ojai, Camarillo, and Simi Valley, the services are contracted from the County.

Because of the technical nature of the subject only the ability of various departments to enforce the standards will insure seismic safety. Trained personnel capable of checking plans and inspection are of utmost importance. Ventura County is fortunate to have civil engineers and a structural engineer on their staff, but this is not true of all departments in the County. The importance of plan checking and inspection should not be underestimated. At the Joint Committee on Seismic Safety May 1972 earthquake conference, these points were made:

Less than 20% of building designs cross the desk of an engineer competent to check them. Of those that are checked competently, half do not meet seismic safety standards.

Failure to meet present codes are caused by: 1) not enough money for building inspection function, and 2) a hack attitude on the part of some professionals. (Robert W. Giese, Building Inspector, Contra Costa County).

Substantial increases in earthquake resistance can be achieved with little increase in cost, if there is proper coordination on seismic safety measures and needs between architects, planners, engineers, and other professionals concerned with the location, design and construction of buildings. (Carl B. Johnson, Consultanting Structural Engineer, Los Angeles).

For meeting seismic safety standards, the approval and inspection of the construction of public schools (excluding State Colleges and Universities) and recently of hospitals is regulated at the state level. The Department of Transportation is responsible for State highways and freeways. The Department of Water Resources is responsible for the safety of dams in California, except Federally owned dams.

FINDINGS

PROBABILITY OF OCCURRENCE

From the evidence and the studies of geologists, the possibility of a major earthquake occurring in or near Ventura County is inevitable. From the past performance of structures in earthquakes it can be assumed that a significant hazard does exist in Ventura County. However, there can be no definitive statement, since information for a local inventory is not available at this time. Such an assessment requires a thorough evaluation of existing structures.

The probability of occurrence can be reduced to a minimum through careful land use planning and adequate reinforcement of structures against seismic forces. Maximum earthquake safety can be achieved through a comprehensive approach. Such an approach would include these areas of concern: "1) formulating engineering standards for new construction, 2) enforcing such standards and 3) reviewing existing structures and repairing or replacing those found hazardous." (Joint Committee, p. 164)

SEVERITY OF THE HAZARD

During an earthquake the greatest cause of death and property loss are structural deficiencies. In the event of an earthquake, the severity of the effects is dependent on the condition and the structural details of the building.

The structural failure of vital and critical facilities can increase the severity of damage. It should be recognized that such facilities as hospitals, fire stations, public buildings and communications centers should remain functional after the earthquake to help mitigate the disaster effects. Other facilities such as dams could have catastrophic effects if they failed.

RESOURCES AFFECTED

Should an earthquake affect the area, there could be substantial loss of lives and property. In addition public utilities, gas, water, and sewage lines could be disrupted and may be difficult to re-establish rapidly.

NATURE OF INFORMATION

There is a wealth of information on the ability of structures to withstand lateral forces and much of this

has been documented in engineering studies of the San Fernando earthquake. However, specific information on Ventura County's seismic structural deficiencies has not been accumulated. Therefore, conclusions in this study are mainly based on experiences of other areas and some studies on the effects of past earthquakes in Ventura County.

OTHER FINDINGS

The implementation of seismic safety is a very complex task and it requires qualified individuals to develop, interpret and enforce the regulations that will insure an acceptable level of risk. The Ventura County Building and Safety Department has employed a structural engineer and several civil engineers. Staff with such expertise is essential for adequate plan checking and inspection of structures. The individual cities should evaluate their own staff capabilities and support up-grading measures if necessary.

OPTIONS

The following are a variety of alternative responses or "options" to this hazard. The appropriateness of each option will depend upon the specific conditions spelled out in the FINDINGS section.

Identification of existing hazard:

1. Survey all structures on a statistical basis to identify and evaluate existing hazard.
2. Identify publicly owned structures, hospitals, schools, fire stations, churches and buildings that could expose a large number of persons to injury in case of structural failure.
3. Evaluate placement and structural design of utility transmission lines and generating and transmission stations.
4. Identify all structures which meet one of these criteria as in need of further consideration as a possible hazard.
 - a. Building was constructed before 1933, or a later designated date established on an evaluation of the areas history with respect to design and standards and effectiveness of enforcement.
 - b. Building lies within a zone designated as probably subject to substantial shaking.
 - c. Buildings constructed with unreinforced masonry and brick walls and wood floors and roofs.

Elimination and prevention of the hazard:

5. Eliminate the most hazardous structures through the removal or reinforcement of the structure against seismic forces. Priorities should be decided based on these criteria: (not in any order of priority)
 - a. Those facilities whose continued performance is critical immediately after an earthquake.
 - b. Those structures whose failure would cause significant numbers of injuries and perhaps substantial loss of life.
 - c. Those structures whose failure would result in an unacceptable level of potential economic loss.

6. Adopt a "parapet" ordinance whereby existing hazardous parapets must be removed or reinforced.
7. Adopt land use policies which would restrict certain structures from being built in ground-shaking hazard zones.
8. Adopt building codes which reflect the most recent findings in the field of structural seismic safety.
9. Support adequate enforcement of the building codes by employing a technically qualified staff.
10. Support any means to insure the general availability of earthquake insurance.

RECOMMENDATIONS
ON OPTIONS

RECOMMENDATIONS ON OPTIONS

The following are recommendations made by various authorities, committees, citizen groups, etc.; which are intended to guide in the selection of options which most appropriately respond to the particular conditions encountered.

CITY/COUNTY PLANNING ASSOCIATION

GENERAL RECOMMENDATIONS

- That all the entities in the county cooperate in further investigation of the hazards affecting the agencies within the county.
- That all people affected by an immediate hazard receive a general notification.
- That the concept of a Special Studies Zone or other similar designation be established for all applicable hazard zones which would require detailed studies of the hazard before certain development or activity could take place.
- That each entity should undertake a general evaluation of its warning and evacuation plans in response to the hazards in this element

SPECIFIC RECOMMENDATIONS

Tsunami

- Recommendation - That each affected entity adopt or update their seismic sea wave warning plan, possibly along the lines of the County Basic Plan.

Tsunami and Seiche

- Recommendation - That vital or critical facilities be restricted in the hazard zone or designed to mitigate the hazard.

Fire

- Recommendation - That each entity adopt the provisions of a comprehensive fire prevention program such as the Fire Safe! program of the County Supervisors Association of California.

Aircraft Accident

- Recommendation - Restrict land uses in the high hazard areas to those having only low population densities

and no critical facilities. Limit facilities with high concentrations of population in the low hazard areas.

Beach Erosion

Discourage buildings and facilities from locating in beach erosion hazard zones, so that the shoreline can undergo its natural fluctuation patterns.

Discourage all uses that would contribute to beach erosion from locating on sandy beaches.

Local governments should coordinate with the County Public Works Department and the Army Corps of Engineers in setting up a county wide beach (sand) management program. Such a program would deal with all aspects of beach management, including the sources of sand. It would anticipate problems dealing with flood control operations and beach erosion prevention measures, conduct relevant studies, emphasize flood plain management as an alternative to flood control and assist local governments in planning in beach erosion hazard zones.

Landslide/Mudslide

Incorporate the use of the landslide/mudslide hazard zones in future land use determinations by avoiding intense development. Require soils investigations and the use of appropriate safeguards in the design.

Fault Displacement

Adopt the Policies and Criteria of the State Mining and Geology Board with Reference to the Alquist-Priolo Geologic Hazard Zones Act in regard to requirement of geologic-seismic investigations prior to approval of any proposed development within the primary and secondary fault zones to prevent development directly over an active fault.

Ground Shaking

Conduct a structural evaluation of all vital and critical facilities to insure conformance to current Uniform Building Code requirements in regard to resistance to ground shaking.

Adopt and provide qualified enforcement of the Uniform Building Code and other appropriate design requirements for all land development.

Liquefaction

Require geologic-seismic and soils engineering investigation of soil liquefaction potential for proposed critical facilities and structures designed for large concentrations of people.

Structural Deficiencies

Develop a program to evaluate the seismic structural safety of existing public and vital facilities and to bring up to the standards of the current uniform building code facilities which are considered hazardous.

Continue to support the adoption and enforcement of the most current provisions of the Uniform Building Code regarding seismic safety.

Subsidence

That Ventura County give all possible support to programs aimed at fulfilling the state's recommendations on subsidence which allow us to knowledgeably assess the degree of hazard it presents.

Expansive Soils

Continue to conduct the existing control programs which have adequately minimized damage from expansive soils.

Flood

Owing to the necessity of Federal Flood Insurance to qualify for loans from federally regulated lending institutions it is recommended that:

Each entity adopt the standards of the National Flood Insurance Act to qualify for or maintain eligibility and that these standards be enforced by those departments having enforcement responsibility.

ADOPTED: August 8, 1974
September 19, 1974

VCAG GENERAL PLAN ELEMENTS POLICY ADVISORY COMMITTEE POLICY RECOMMENDATIONS SEISMIC AND SAFETY ELEMENT

GENERAL RECOMMENDATIONS

1. All the entities in the county continue to cooperate in investigation and alleviation of the seismic and safety hazards affecting the county.
2. All people affected by a hazard receive a general notification of their inclusion in a hazard zone. *Hazard Zone: A General Geographic Area Potentially Affected by the Hazard.

3. The concept of a Special Studies zone, or other similar designation, be established for all applicable hazard zones which would require detailed studies of the hazard potential before certain types of development or activity could take place.
4. Vital and critical public services should be required, if located within the Special Studies zone, to conduct detailed studies of the hazard and be required to take the appropriate action to alleviate potential hazard impacts.
5. In each entity there be a general evaluation and updating yearly of its warning and evacuation plans in response to the hazards defined and described in this General Plan Element.
6. That all entities seek, through cooperative action, to adopt Uniform Building Codes that include the appropriate safeguards for the hazard potentials existing in their jurisdiction. The standards should be established on a uniformly consistent basis throughout the County.

SPECIFIC RECOMMENDATIONS

Tsunami - Adopt or update their seismic sea wave warning plan, along the lines of the nationally recognized "County Basic Plan."

Tsunami and Seiche - *Seiche is wave action in an enclosed body of water, e.g. lake or harbor. Vital or critical facilities be restricted in the hazard zone.

Fire - Adopt the provisions of the comprehensive fire prevention program "Fire Safe" program of the County Supervisors Association of California.

Flood - Adopt the standards of the "National Flood Insurance Act" to qualify for or maintain eligibility and that these standards be enforced by those departments having enforcement responsibility.

Aircraft Accident - Restrict land uses in the high hazard areas to those having only low population densities and no critical facilities. Limit facilities with high concentrations of population in the low hazard areas. Avoid locating airports in highly populated areas.

Beach Erosion - Discourage buildings and facilities from locating in beach erosion hazard zones, so that the shoreline can undergo its natural fluctuation patterns. Discourage all uses from locating on sandy beaches which would tend to cause beach erosion. Local governments should coordinate with the County of Ventura, the Army Corps of Engineers and others in setting up a county wide beach (sand) management

program. Such a program would deal with all aspects of beach management, including the sources of sand. It would anticipate problems dealing with flood control operations and beach erosion prevention measures. The program would emphasize flood plain management as an alternative to flood control and assist local governments in planning in beach erosion hazard zones.

Landslide/Mudslide - Incorporate the use of the landslide/mudslide hazard zones in future land use determinations by avoiding intense development. Require soils investigations and the use of appropriate safeguards in the design of structures.

Fault Displacement - Adopt the Policies and Criteria of the State Mining and Geology Board with Reference to the Alquist-Priolo Geologic Hazard Zones Act in regard to requirement of geologic-seismic investigations prior to approval of any proposed development within the primary and secondary fault zones to prevent development directly over an active fault.

Ground Shaking - Conduct a structural evaluation of all vital and critical facilities to ensure conformance to current Uniform Building Code requirements in regard to resistance to ground shaking. Adopt and provide qualified enforcement of the Uniform Building Code and other appropriate design requirements for all land development.

Liquefaction - Require geologic-seismic and soils engineering investigation of soil liquefaction potential for proposed critical facilities and structures designed for large concentrations of people.

Structural Deficiencies - Develop a program to evaluate the seismic structural safety of existing public and vital facilities and to bring up to the standards of the current Uniform Building Code facilities which are considered hazardous. Continue to support the adoption and enforcement of the most current provisions of the Uniform Building Code regarding seismic safety.

Subsidence - Support programs aimed at fulfilling the State's recommendations on subsidence as referenced in The Urban Geology Master Plan for California, which allows us to knowledgeably assess the degree of hazard it presents.

Expansive Soils - Continue to conduct the existing City and County control programs which have adequately minimized damage from expansive soils.

ADOPTED BY THE GENERAL PLAN
ELEMENTS POLICY ADVISORY
COMMITTEE - 9/4/74

The following is from:

CALIFORNIA DIVISION OF MINES AND GEOLOGY,
Urban Geology Master Plan, 1973, Pages 51-68.

RECOMMENDATIONS FOR REDUCING GEOLOGIC HAZARDS LOSSES IN CALIFORNIA

General Statement

Section 3 of this report describes the ten principal geologic problems that threaten California: the geologic nature of each problem; statewide distribution, by severity levels; history of losses; the most effective measures for reducing the losses from problems; the agencies that deal with the problem; and the state of the art in coping with each problem. Section 3 is, in effect, a capsule inventory of what we know about the problems.

Section 4 lists, in broad form, the action programs that can be implemented to reduce future losses resulting from each geologic problem. These action programs constitute the recommendations of the Urban Geology Master Plan for California. The recommended programs are of two kinds: those that propose to improve the state of the art and to develop new and greater capabilities for dealing with California's geologic problems on both the technical and the non-technical levels; and those that propose to expand the application of present state-of-the-art procedures to reduce losses further. Many of the recommended programs are presently active to some degree, but need to be expanded or accelerated; others need to be instituted.

The recommended actions involve four broad types of objectives, arranged roughly by time-sequence relative to the expected occurrence of particular geologic hazard events:

1. Avoid or prevent damage from future events by knowing the nature and location of probable events, taking steps to control those events, and guiding human activities away from hazardous areas in which it is not feasible to control the hazards.
2. Minimize unavoidable or unpreventable losses by requiring thorough analysis of the geologic environment prior to design, then provide safe design, construction, and maintenance practices by adequate codes and ordinances.
3. Take emergency action to save lives and property during or immediately following any particular disastrous event.
4. Take longer-range recovery action following a particular event, to study its losses, reestablish normal life, and rebuild.

Recommended action programs are listed or referenced for each of the 10 urban geologic problems together with recommendations as to which organizations should implement each program.

Priorities—as to which problem should be considered first, in which localities actions should be started first, which loss-reducing actions should be initiated first, or which action organization should act first to initiate its programs—are considered in Section 5.

Table 4, "Loss-reduction functions", lists the seven main functions that can and should be performed to reduce losses from geologic problems. All of the action programs recommended for specific geologic problems in the pages following table 4 fall within these seven

functions. The recommended actions are presented by problem, in the order given in table 4.

The loss-reduction functions in table 4 and the recommendations that follow are not equally important in reducing losses from each of the 10 geologic problems: a given function may apply only indirectly to certain geologic problems, or it may be adequately performed now.

Loss-reduction functions cannot be compared to each other in importance for reducing the losses from any single geologic problem. The functions are basically sequential in application, like links in a chain of operation: none does the whole job itself, yet none can be neglected entirely.

The variability of importance of the functions within and between the several geologic problems is apparent from the number and type of programs that are recommended within each function's heading, problem by problem.

This classification of loss-reduction programs repeatedly emphasizes two separate types of actions that are necessary before a recommended function is indeed accomplished:

1. **DEVELOP CAPABILITY.**
Learn how to carry out the needed program. Develop the capability or improve the state-of-the-art, and develop or evolve a standard procedure for accomplishing the program. This capability must be made available to those responsible for doing the job.
2. **DO THE JOB.**
Properly apply the capability to avoid, prevent, or correct the problem.

The need for this obvious two-step approach is emphasized in the recommendations to produce consistent and complete socio-economic analysis information for each geological problem. First, to develop needed capability, a standard terminology needs to be devised, and a standard format developed for collecting and recording the needed kinds of data, in terms of the units to be used; a standard procedure needs to be devised designating sources to be canvassed and organizations responsible for collecting, collating, and storing the information. Otherwise the record will continue to be made up of fragmentary data about various kinds of losses, which may otherwise be combined in unknown ways with other loss (or loss-reduction) data, and may contain unexpressed assumptions and incompatible units which are incomplete or overlapping in some time-spans or localities. This procedure should be developed with broad participation so as to be generally acceptable, and then made available to all concerned.

Second, the many agencies responsible under the developed procedure must effectively perform the indicated tasks to collect the socio-economic data in the accepted manner.

Table 4. Loss-reduction functions.

A. DATA FUNCTIONS

1. Research programs to gather, prepare, and interpret data.
2. Information dissemination.

B. PLANNING FUNCTIONS

1. Land use planning.
2. Recovery planning.

C. ENGINEERING FUNCTIONS

1. Planning and design.
2. Construction.

D. ENABLING FUNCTIONS

1. Political and administrative action.
a. Authority, policy guidance, action data.
b. Resources (funds, manpower) to conduct action programs.
2. Coordination and operational guidance (e.g., criteria, model language).

E. ENFORCEMENT FUNCTIONS

1. Governing body and administrative review and management.
2. Operational inspection and enforcement.

F. EMERGENCY-ACTION FUNCTIONS

1. Overall coordination, definition, and guidance.
2. Contingency planning, preparation, and testing.
3. Response.
4. Post-disaster review.

G. OVERALL COGNIZANCE AND COORDINATION FUNCTIONS

1. Monitor progress of loss-reduction measures and techniques.
2. Provide overall coordination mechanisms.

Recommended Programs

The following section presents the action programs recommended for immediate implementation to reduce losses from the ten geologic problems considered in the Urban Geology Master Plan project. Collectively, these recommendations constitute the principal end product of the California Urban Geology Master Plan.

The ten geologic problems are arranged in descending order of potential total dollar loss in the state, including dollar-equivalent life-loss, property damage, and intangible losses, from 1970 to the year 2000 if no change is made in the type and level of loss-reduction measures being taken in 1972. (See table 1, in Section 1.) To the extent the amount of potential loss represents the potential benefit if loss-reduction measures could be 100 percent successful, this ranking represents one approach to an order of priority for implementing Urban Geology Master Plan recommendations.

The recommended programs are classified according to the outline presented in table 4. Detail varies from heading to heading and between geologic hazards, according to the nature of the hazard and the applicability or effectiveness of the several types of recommendations.

The numbers in parentheses following each recommended program indicate:

- (1) This is a new program.
- (2) This is an enlargement of a program now active in some places or to some degree in California; it should be expanded in scope, or extended to other jurisdictions, or accelerated to completion, above its 1972 levels by at least 100 percent.
- (3) This represents a continuation of a program now active, at about its 1972 scope, coverage, and emphasis.

Recommendations in bold-face type are the Major Recommendations of the Urban Geology Master Plan—those programs that stand to produce the largest amount of loss reduction in each problem if pursued vigorously.

Abbreviations Used in This Section

STATE AGENCIES

CDP	California Division of Forestry (in Department of Conservation)
CDM	California Division of Highways (in Department of Public Works)
CDMO	California Division of Mines and Geology (in Department of Conservation)
CDOO	California Division of Oil and Gas (in Department of Conservation)
CIR	California Council on Intergovernmental Relations
DC	California Department of Communication
DI	California Department of Insurance
DGS	California Department of General Services
DHCD	California Department of Housing and Community Development
DNOD	California Department of Navigation and Ocean Development
DPR	California Department of Parks and Recreation
DPW	California Department of Public Works
DRE	California Department of Real Estate
DVA	California Department of Veterans Affairs
DWR	California Department of Water Resources
OEC	California Governor's Earthquake Council
JCSS	Joint Committee on Seismic Safety of the California Legislature
MOB	State Mining and Geology Board
OAC	California Office of Architecture and Construction (in Department of General Services)
OES	California Office of Emergency Services
OIM	Office of Intergovernmental Management
OPR	California Office of Planning and Research
SLD	California State Lands Division

FEDERAL AGENCIES

BLM	U.S. Bureau of Land Management
DCPA	U.S. Defense Civil Preparedness Agency
EPA	U.S. Environmental Protection Agency
FHA	U.S. Federal Housing Administration (in Department of Housing and Urban Development)
FLA	U.S. Federal Insurance Administration (in Department of Housing and Urban Development)
HUD	U.S. Department of Housing and Urban Development
NASA	U.S. National Aeronautics and Space Administration
NOAA	U.S. National Oceanic and Atmospheric Administration
NSF	U.S. National Science Foundation
ORF	U.S. Office of Emergency Preparedness
ONR	U.S. Office of Naval Research
SCS	U.S. Soil Conservation Service
USBR	U.S. Bureau of Reclamation
USCE	U.S. Corps of Engineers (in Department of Defense)
USCG	U.S. Coast Guard
USDA	U.S. Department of Agriculture

USFS U.S. Forest Service
USGS U.S. Geological Survey

LOCAL GOVERNMENT AND PRIVATE SECTOR ORGANIZATIONS

ASG	Association of Engineering Geologists
ATA	American Institute of Architects
AME	American Institute of Mining, Metallurgical, and Petroleum Engineers
AIP	American Institute of Planners
ASCE	American Society of Civil Engineers
CSAC	County Supervisors Association of California
CSL	California Savings and Loan League
DWP	Los Angeles City Department of Water and Power
FAIR	Fair Access to Insurance Requirements
KBO	International Council of Building Officials
LEC	League of California Cities
MWD	(Los Angeles Area) Metropolitan Water District
PG&E	Pacific Gas and Electric Company
SCE	Southern California Edison Company
SEAC	Structural Engineers Association of California

Recommended Programs

Recommended Agencies

II. LOSS OF MINERAL RESOURCES (DUE TO URBANIZATION)

A. DATA FUNCTIONS

1. Research programs to develop data on mineral deposits.

a. Geologic processes that cause mineral deposits to form where they are. (Not applicable to loss-reduction.)

b. Distribution of mineral resources.

Review, update, and improve (wherever warranted and feasible) maps and descriptions of all known deposits of useful or potentially useful minerals within 100 miles (or commercial haul distance if shorter) of urban areas throughout California. Include all undepleted deposits, whether formerly, currently, or potentially active, regardless of their stage of development or value of past production, if any. Include metals, industrial mineral substances, and mineral fuels.

CDMG*, CDOG, USBM, USGS, County geologists (consultants), Mining associations

i. Statewide scale: (1:250,000-1:1,000,000)¹

CDMG*, USGS

ii. County/Regional scale: (1:62,500-1:125,000)²

CDMG*, USGS

iii. Detail or quadrangle scale: (1:12,000-1:24,000) for urban area deposits, only³

CDMG*, Counties, Cities

c. Develop socio-economic information and analyses.

i. Establish a standard procedure for gathering, collating, and reporting data on the economic and social costs of mineral deposit loss problems—including both loss and loss-reduction costs. The aim is to enable the systematic collection of all pertinent data as it is available, in consistent form so that information collected at different times and places can be correlated and used in statewide compilations and analyses.⁴

CDMG, USBM*, Universities

ii. For every urban region in California and for those outlying regions that have mineral resources serving urban areas, complete a standard economic analysis report, including demand projections, on the problem (or potential problem) of loss of mineral deposits per procedure established under recommendation A-1-c-1.⁵

CDMG, Regional planning agencies, Counties*, Cities

d. Develop research information on engineering problems associated with loss of mineral resources

Determine probabilities or limitations of possible development of each mineral (or mining) district, considering limits of valuable material, and removal problems. Consider also forecasts of market demand and any potential engineering problems facing removal of the valuable materials.⁶

CDMG, USBM*, USGS, Mining associations, Counties

e. Case-study projects: Conduct research study of major cases where mineral resources have been lost, or threatened to be lost, due to urbanization processes (e.g., one study in southern California area, one in San Francisco Bay area).

CDMG*, USBM, Minerals industry, City and county, planning departments

2. Information-dissemination programs.

a. General public information program.

Prepare and distribute basic educational materials about the economic, environmental, and social relationships of mineral resources to urban development.

CDMG*, USBM, USGS, Minerals industry

b. Information clearinghouse and data-bank program.

Loss-Reduction Programs

1. EARTHQUAKE SHAKING

The Governor's Earthquake Council has recommended a comprehensive program to reduce losses from seismic events in "First Report of the Governor's Earthquake Council, November 21, 1972".

The Joint Committee on Seismic Safety of the California Legislature is conducting various investigations and has issued several progress reports directed primarily to possible legislative actions to reduce losses from seismic events. A number of pieces of seismic safety legislation were passed in 1971 and 1972 reflecting the Joint Committee's work, and more are expected to be enacted in 1973 and future years. The

final Joint Committee report is due July 1, 1974.

Rather than duplicate the recommendations of these organizations, the Urban Geology Master Plan refers to the above publications and endorses their recommendations.

One additional recommendation of the Urban Geology Master Plan is to extend the scope of the successor body (Governor's Earthquake Council Recommendation 26 in the *First Report*, page 55) to consider, in addition to seismic hazards, all the other geologic problems covered in this report except loss of mineral resources and flooding.

Recommended Programs

Recommended Agencies*

A-1. (Not applicable)

G. OVERALL COGNIZANCE AND COORDINATION FUNCTIONS

Extend scope of successor body to GEC and of JCSS after June 30, 1974 (Recommendation 26 in GEC, 1972, page 55) to provide continuing cognizance over loss-reduction programs for all geologic problems except loss of mineral resources and flooding.¹

(body to be established)

¹ Essentially a new program

* = Lead or co-lead agency.

¹ Essentially a new program

² Expansion of 1972 programs

³ Continue program at 1972 level

⁴ = Lead or co-lead agency.

Bold-face type = Major recommendation of Urban Geology Master Plan

Recommended Programs	Recommended Agencies	Recommended Programs	Recommended Agencies
i. Continue to serve as clearinghouse and provide data bank service for all information on California mineral resources. ¹	CDMG*, USBM	of mineral resource conservation; also suggestions for effective administration of that element. ²	CDMG, AIP, Cities, Counties
ii. Expand the types of mineral resource information covered in the data bank to include those recommended in this section. ³	CDMG*, USBM, USGS	e. Provide model of mineral recovery zone ordinance (cf. Riverside County's MR zone), and guidelines for administering it effectively. ²	CDMG, AIP, CIR*, OPR, Cities, Counties
B. PLANNING FUNCTIONS			
1. Land-use planning.		d. Produce case-studies or other guidance for applying mineral resource information in environmental impact considerations. ²	CIR, OPR*, CDMG, Cities, Counties
a. Produce publication describing problems of mineral deposit loss due to blocking of access before the valuable materials can be removed, and the implications of this problem for land-use planning and public policy. ¹	CDMG*, USBM, USGS, AIP, CIR, OPR	E. ENFORCEMENT FUNCTIONS (Not applicable)	
b. Adopt practice of using mineral resource information in determining land-use capability and in the land-use planning, zoning, and permitting procedures of local governments and land-custody agencies. Strengthen mineral resources aspects of conservation elements in general plans, and emphasize their application. ²	City and county planning* departments Land-custody agencies: BLM, USBR, DPR, SLD	F. EMERGENCY ACTION FUNCTIONS (Not applicable)	
2. Recovery planning.		G. OVERALL COGNIZANCE AND COORDINATION FUNCTIONS	
Apply long-range concepts of conservation, reclamation, and reuse of mineral resource lands in long-range community and land-custody planning procedures. ²	CDMG, USBM, City and county planning departments* Land-custody agencies, BLM, USBR, SLD	1. Make periodic evaluation of progress on recommendations in this section and publish annual status reports. ¹	CDMG*, OPR
C. ENGINEERING FUNCTIONS		III. LANDSLIDING	
Improve quarrying and mining procedures to enable the removal of mineral materials within the urban environment with minimum adverse effects. Also improve mining procedures to facilitate long-range policies of multiple sequential uses of mineral deposit lands. ¹	USBM*, CDMG, Minerals industry— firms and associations, Universities, Cities, Counties, AIME	A. DATA FUNCTIONS	
D. ENACTING FUNCTIONS		1. Research programs to develop data on landsliding.	
1. Political and administrative actions.		a. Research into geologic and other natural processes and conditions that cause or relate to slope stability and landslide movement and their interrelationships.	CDMG*, USGS*, Universities, AEG, DWR, USBM, CDH
a. Provide authority, policy, and guidance.		i. Develop state of the art, including new instrumentation, to enable analysis of old landslides as to their history and date(s) of prior movement, and their propensity for renewed movements. ¹	USGS*, CDMG*, Universities, DWR, CDH
i. Adopt strengthened conservation element of general plans, incorporating long-range approach to mineral resource utilization. ²	City councils, Boards of Supervisors	ii. Develop and improve the state of the art and inexpensive instruments for predicting and detecting incipient renewed movement in known landslides for warning purposes. ¹	Private sector*, Universities, CDH, DWR
ii. Adopt mineral resources zoning ordinance and procedures and practices for making it effective. ²	City councils, Boards of Supervisors	iii. Devise workable procedure and criteria to determine the relative stability of slopes. The criteria must be applicable in the field, and should relate the stability characteristics to the uses to which the area can be put. ²	CDMG*, USGS*, AEG, Cities, Counties
b. Provide resources (funds and manpower) to enable effective administration of the strengthened mineral resources element in the general plan and the mineral resources zoning ordinance.	City councils, Boards of Supervisors	b. Evaluate the varying degrees of slope instability in the urban areas of California.	
2. Coordination and operational guidance.		i. Compilation (statewide) scale program (1:250,000–1:1,000,000). ¹	CDMG*, USGS
a. Develop and make information available to land-use planners, zoning administrators, and mineral producers, on proven techniques for developing and extracting mineral deposits in urban areas, applying available geotechnical and socio-economic information about mineral deposits. The aim is to minimize undesirable consequences to the physical, economic and social environment, both immediate and long-range, of mining and quarrying operations. Include considerations of designing the quarry development plan, and managing the long-range reclamation of depleted sites so they will be suitable for high-demand urban uses. ²	CDMG, USBM, AIP, AEG, Cities, Counties, CSAC*, LCC	ii. County/regional scale program (1:62,500–1:125,000). ¹	CDMG*, USGS, County consultants
b. Establish guidelines, and produce model language for effective conservation element of the general plan that properly treats problems	CIR*, OPR	iii. Detail or quadrangle scale program (1:12,000–1:24,000). ²	CDMG*, USGS*, Cities, Counties, Consultants
		iv. Project-scale mapping for land-use permit decisions or construction purposes (1:1200–1:12,000). ²	Consultants for local governments or developers
		e. Develop socio-economic information and analyses.	
		i. Establish standard procedure for gathering and compiling figures on landslide damage loss and costs of remedial efforts, for accurate and comparable statistics; devise a form that can be used and compiled statewide, and designate an information clearinghouse. ¹	ICBO*, AEG, ASCE, LCC, CSAC, OES, SEAOC, DI, CIR

¹ Essentially a new program
² Expansion of 1972 programs
³ Continue program at 1972 level

* = Lead or co-lead agency
 Bold-face type = Major recommendation of
 Urban Geology Master Plan

¹ Essentially a new program
² Expansion of 1972 programs

* = Lead or co-lead agency
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Recommended Programs	Recommended Agencies	Recommended Programs	Recommended Agencies
<p>ii. For every reportable landslide occurrence, complete a standard report for permanent record and clearinghouse use.¹</p> <p>d. Perform engineering response research.</p> <p>i. Investigate behavior of surficial materials at proposed construction sites to determine safe design of foundation and structure. Consider effects of site-preparation work and control accordingly.²</p> <p>ii. Investigate design and construction standards for foundation and structure to be built at any proposed site, relative to the expected stability of the geologic setting.³</p> <p>e. Event-study opportunities.</p> <p>i. Whenever a landslide moves significantly, or damages a foundation or structure, conduct detailed study of the geologic materials and, if present, foundations and structures. Make information on results of studies readily available.²</p> <p>ii. During any post-earthquake investigation, search immediately for incipient landslides that may be triggered by aftershocks.³</p> <p>2. Information-dissemination programs.</p> <p>a. General public information program.</p> <p>Prepare and distribute basic educational materials about landsliding in general, emphasizing local and regional applications, and what the homeowner should know and do about landslides, both before and after they occur.²</p> <p>b. Information clearinghouse and data-bank program. Gather, store and disseminate all pertinent information on landsliding.¹</p>	<p>City and county agencies and/or officials</p> <p>Consultant for local government site-approval section, Consultant for builder, Universities, AEG, ASCE</p> <p>Local government site-approval section, Consultant for builder</p> <p>CDMG*, USGS*, City and county building officials, Clearinghouse</p> <p>CDMG*, USGS, City and county personnel</p> <p>CDMG*, USGS, CSLL, DI, AEG, ASCE, DRE*, FRA</p> <p>CDMG*, USGS</p>	<p>D. ENABLING FUNCTIONS</p> <p>1. Political and administrative actions.</p> <p>a. Provide authority, policy guidance.</p> <p>i. Adopt strengthened safety and seismic safety elements in general plan, incorporating improved landslide considerations.²</p> <p>ii. Adopt latest, improved version of grading ordinance (see A-4-a, b).³</p> <p>b. Provide funds and staff to make land-use plan effective, and to enable zoning and grading ordinances to be enforced.³</p> <p>2. Coordinated, informational guidance.</p> <p>a. Produce model safety element for local general plans, especially as it deals with slope-stability problems.¹</p> <p>b. Periodically update model grading ordinance, especially as it deals with landslide problems, with guidance on how it can be applied effectively, including case studies of successful grading ordinance enforcement practice.²</p> <p>c. Assemble and distribute case-studies, and other informational materials on applications of landslide information in environmental impact considerations, including case studies of successful practice.³</p> <p>d. Produce interpretive publication, alerting and orienting planners and administrators to the significance and usefulness of geotechnical information on landsliding and on the engineering response, and on its application in land-use planning and decision making.¹</p> <p>E. ENFORCEMENT FUNCTIONS</p> <p>1. Administrative follow-through; management control.</p> <p>a. Strengthen local government programs and capabilities for effective inspections of grading practices, including requirement of pre-construction geological study of slope stability conditions at site.¹</p> <p>b. Maintain integrity of zoning and grading ordinances (as they apply to landsliding) in arriving at individual land-use decisions.²</p> <p>2. Conduct on-site inspections of building sites as necessary to assure that the various actions to prevent damage from landsliding are properly taken, as required by safety regulations, and zoning and grading ordinances.³</p> <p>3. Public and private lending institutions should require either a geologic report on the stability of structural sites or a policy of landslide insurance prior to the approval of financing in areas subject to landsliding.¹</p> <p>F. EMERGENCY ACTION FUNCTIONS (Shorely applicable)</p> <p>G. OVERALL COGNIZANCE AND COORDINATION FUNCTIONS</p> <p>The status of landslide hazards in California should be determined and reported upon annually by the appropriate State agency or agencies. Landsliding should be included among the geologic hazards to be considered by the successor body to the GEC and JCSS after June 30, 1974 (Recommendation 26 in GEC, 1972, p. 55).¹</p>	<p>City councils, Boards of Supervisors</p> <p>City councils, Boards of Supervisors</p> <p>City councils, Boards of Supervisors</p> <p>CIR*, OPR, CDMG, CSAC, LCC, AEG</p> <p>ICBO*, CDMG, CIR, CSAC, LCC, AEG, ASCE</p> <p>USGS, CDMG, OPR*, AEG, ASCE, OIM, CIR</p> <p>CDMG*, USGS, AEG, ASCE</p> <p>City councils, Boards of Supervisors</p> <p>City councils, Boards of Supervisors, Appeals Boards</p> <p>City and county grading inspectors; Foundation and construction inspectors</p> <p>FHA, DVA, Private lending institutions</p> <p>CDMG*, MGB</p>
<p>C. ENGINEERING FUNCTIONS</p> <p>In planning and designing public works structures, adopt standard procedure of considering threat of landslide, and modify structure as necessary.²</p>	<p>Dam-building agencies (USCE, DWR, BLM, USBR, USFS), Road-building agencies (DPW)</p> <p>DI*, FIA*, DWR (Insurance coordinator), DRE, FAIR, DHCD, JCSS, DVA, FIA, Insurance associations</p>		

¹ Essentially a new program
² Expansion of 1972 programs
³ Continue program at 1972 level

* = Lead or co-lead agency.
 Bold face type = Major recommendation of Urban Geology Master Plan

¹ Essentially a new program
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Recommended Programs

N. FLOODING

The natural causes and processes of flooding lie mainly in the fields of weather science and hydrologic engineering, largely outside the field of strictly geotechnical science, so are treated only generally in the Urban Geology Master Plan. On the other hand, the methods and responsibilities for reducing life and property losses from flooding are similar in many respects to those for several of the other geologic problems included in this study. The magnitude of expectable flooding losses—\$6.5 billion by 2000, fourth among the 10 geologic problems considered in this study—justifies further consideration of all feasible loss-reduction actions.

It is recommended that the Department of Water Resources, in coordination with other State, federal, and local agencies, make an assessment of existing flood damage prevention measures, future needs, and programs to meet the needs. Loss-reduction measures which should be considered include:

- Weather research.
- Hydrologic research.
- Flood zone mapping, at various scales.
- Consistent, complete socio-economic data on flood damage.

- Improved design and construction practices for dams, levees, weirs.
- Improved public information, especially about "drainage problems" (local flooding).
- Flood information clearinghouse, data-bank.
- Flood zone ordinances.
- Flood insurance policy and practice.
- Flood-zone construction lending policies and practices.
- Traditional government policies regarding: emergency flood grants, low-cost recovery loans, tax forgiveness.
- Standards for feasibility studies prior to authorizing flood-control works (e.g. Framework Study Program).
- Implementation of flood-zone land-use laws for reduced land-use capability under more restrictive flood-zone regulations.
- Model language to permit inclusion of flood and drainage problems in general plan, safety elements.
- Measures for enforcing flood-zone regulations.
- Standards for "floodproof" construction.
- Guidance for local governments to include flooding and drainage problems in their emergency-response planning.
- Provide for ongoing top-level cognizance, coordination of all measures to reduce losses from flooding.
- Public purchase of flood-prone areas for open space and park land in lieu of construction of flood-control works.

V. EROSION ACTIVITY

Recommended Programs

Recommended Agencies

A. DATA DEVELOPMENT FUNCTIONS

1. Develop research data on erosion.

a. Research into technical, scientific processes that cause or affect erosion.

i. The geologic processes that contribute to erosion are relatively well known and do not warrant high-priority research programs. The erosion and sedimentation problems that accompany flooding, landsliding, and volcanic events should be considered during research in those problems.¹

ii. Coastal erosion processes are more specialized and require research into basic processes and factors aimed at prevention and control measures, especially in urban areas.²

iii. The many factors that contribute to erosion problems of surficial geologic units under various conditions, and their relationships, should be identified and listed for systematic application in studies of erosion problems in California, including local government planning projects.³

b. Extend inventory of knowledge about erosion in California, including coastal erosion. Those types of soils and rock units that are especially susceptible to erosion under natural, undisturbed conditions should be mapped and described throughout California, and especially in areas subject to coastal erosion.

Appropriate research agencies

USGS, USCE*, DNOD, CDMG, Universities

SCS

SCS*, USCE*

¹ Essentially a new program
² Expansion of 1972 programs
³ Continue program at 1972 level

* = Lead or co-lead agency
 Bold face type = Major recommendation of Urban Geology Master Plan

Recommended Programs

Recommended Agencies

i. Statewide compilation scale (1:250,000-1:1,000,000).¹

ii. County/regional scale (1:62,500-1:125,000).²

iii. Detail or quadrangle scale, especially in coastal erosion areas (1:12,000-1:24,000).³

iv. Project-scale mapping, for land-use permit decisions or construction purposes (1:1200-1:12,000).³

e. Develop socio-economic analysis information.

i. Develop a standard procedure for collecting erosion-loss figures separate from landslide and flooding-loss figures.¹

ii. Collect and compile reliable figures (per A-e-i) on losses due to erosion, and the costs of erosion-preventive and remedial measures, for standard reporting areas and periods.¹

d. Research into engineering response to erosion. Standard engineering practice and state of the art, in predicting erosion danger and in devising measures to control it, is effective and should be applied without exception, considering erosion caused by construction projects, and ongoing erosion in adjacent areas that threatens those projects.³

2. Information-dissemination program.

a. General public information.

Produce an updated, interpretive general purpose primer discussing California's erosion problems as geological hazards. Emphasize the geotechnical nature of the problem, related factors, what can and should be done to reduce losses, and what all this means to the urban area in general, and the homeowner in particular.³

b. Information clearinghouse, data-bank program.

Improve present information-handling capability and procedures and establish regular ongoing function as clearinghouse for all information about erosion in California.¹

B. PLANNING FUNCTIONS

1. Land-use planning.

a. Erosion-prone conditions of the undisturbed surface are rarely threatening enough to influence land-use planning. However, procedures for dealing with those rare situations in which an important erosion threat is inherent in local surficial conditions should be made known to all planners.³

b. Procedures should be developed for dealing with land-use implications of erosion of coastal cliffs and near-shore features, and model language provided to all planning agencies.³

2. Recovery planning.

a. Include erosion-damage loss among the geologic losses covered by recommended broad-coverage natural disaster insurance program.¹

C. ENGINEERING FUNCTIONS

1. Make erosion prevention and control considerations part of design and construction practice for drainage works (e.g., storm drains, culverts, bypass or overflow channels).³

2. Plan, design, and build coastal erosion control structures (e.g., seawalls).

Consultants for local governments, Developers

SCS

Local government

Universities, AEG, ASCE

SCS*, USDA

SCS

SCS*, CIR, OPR, AIP, LCC, CSAC, AEG

OPR, CIR*, USCE, AIP, LCC, CSAC, USGS, CDMG, AEG

FIA*, DI*, FHA, DVA, Insurance industry

Public works agencies, all levels of government, Contractors

USCE*, DNOD

¹ Essentially a new program
² Expansion of 1972 programs
³ Continue program at 1972 level

* = Lead or co-lead agency
 Bold face type = Major recommendation of Urban Geology Master Plan

Recommended Programs	Recommended Agencies
groins, revetments) that have been determined to be necessary and feasible. ³	
D. ENABLING FUNCTIONS	
1. Adopt improved land-use plans, grading ordinances, and building codes that incorporate model provisions for dealing with erosion, and provide sufficient funds to carry out work programs. ²	City councils, Boards of Supervisors
2. Improve guidelines and models for proper consideration of erosion in grading ordinances and building codes; include model procedures for enforcing the ordinances and codes; include considerations of potential erosion damage in environmental impact procedures. ³	CIR*, OPR, SCS, ASCE, AEG
E. ENFORCEMENT FUNCTIONS	
Carry out inspection procedures relative to erosion problems, to enforce compliance with building codes and grading ordinances. ³	City and county building and grading department inspectors
F. EMERGENCY-RESPONSE FUNCTIONS (Not applicable)	
G. OVERALL COGNIZANCE AND COORDINATION	(body to be established)
The status of erosion problems in California should be determined and reported upon annually by the appropriate State agency or agencies. Erosion activity should be included among the geologic hazards to be considered by the successor body to the GEC and JCSS after June 30, 1974 (Recommendation 28 in GEC, 1972, p. 55).	

VI. EXPANSIVE SOILS

The Subdivision Map Act requires that soils reports be made before subdivisions are approved unless the requirement is waived by local government. Soils reports include detection of expansive soils so that proper action can be taken. The measures that practically eliminate danger of structural damages in expansive soils are relatively inexpensive, well known, and reliable. As long as local officials are adequately funded and diligent in requiring that the soils report information be used properly, losses due to expansive soils can be minimized.

Detailed recommendations of programs to reduce losses from expansive soils are unnecessary in the Urban Geology Master Plan.

VII. FAULT DISPLACEMENT

The recommendations of the Governor's Earthquake Council to reduce losses from seismic events (GEC, 1972) also cover losses from fault displacement.

Likewise, the work of the Joint Committee on Seismic Safety of the California Legislature to generate legislative and other actions to reduce losses from seismic events will also cover losses from fault displacement.

In 1972, Chapter 7.5, the Alquist-Priolo Geologic Hazard Zones Act, proposed by the JCSS, was added to Division 2 of the Public Resources Code. Its purpose is to establish policies and criteria to assist cities, counties, and state agencies in providing for public safety in hazardous fault zones. In 1973, special studies zones are being delineated to encompass potentially hazardous faults in California by the State Geologist. By December 31, 1973,

the State Mining and Geology Board will have developed policies and criteria to be used in approving all proposed new real estate developments or structures for human occupancy to be placed in the designated special studies zones.

Rather than duplicate these efforts, the Urban Geology Master Plan refers to the publications of the GEC, JCSS, and the Alquist-Priolo Act project and endorses their recommendations and procedures.

VIII. VOLCANIC HAZARDS

A. DATA DEVELOPMENT FUNCTIONS

- Research programs to develop data on volcanic hazard phenomena.
 - Field and laboratory research in geotechnical processes involved in volcanism and the forms of volcanic phenomena that occur in California. Apply results of volcanic research conducted outside California in reducing potential volcanic losses in the state. Develop procedures and instruments necessary for a volcanic warning system.¹
 - Update and refine maps and text descriptions of potential volcanic hazard areas in California. Develop data on probable recurrence and projected damage levels, wherever damage is possible.²
 - Statewide scale: update as feasible
= (1:250,000-1:1,000,000)¹
 - County/regional scale program
(1:62,500-1:125,000)¹
 - Detail or quadrangle scale program
(1:12,000-1:24,000)¹
 - Gather socio-economic information and analyses.
Develop standard procedure for gathering consistent and meaningful data on volcanic hazard losses. Whenever volcanic events occur, gather and analyze the necessary socio-economic data.¹
 - Whenever volcanic eruptions occur in California or nearby states, study site and surrounding region to understand the processes involved and to improve capability for predicting that type of event.¹
- Information dissemination programs
 - Prepare and distribute basic educational materials about volcanic hazards in general, emphasizing local and regional applications and what local residents should know and do about them.¹
 - Establish a clearinghouse and data-bank program for information on volcanic hazards.¹

B. PLANNING PROGRAMS

- Land-use planning
Volcanic hazards in California occur primarily in rural areas where land-custody agencies and utilities should consider the threat in their land-use plans.¹
- Long-range recovery planning.
Extend natural disaster insurance program to cover damage from volcanic phenomena.¹

¹ Expansion of 1972 programs
² Continue program at 1972 level
³ = Lead or co-lead agency

Bold face type = Major recommendation of Urban Geology Master Plan

¹ Essentially a new program
² Expansion of 1972 programs
³ = Lead or co-lead agency

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Recommended Programs	Recommended Agencies	Recommended Programs	Recommended Agencies
C. ENGINEERING FUNCTIONS		v. Correlate tsunami-generation research with fault-displacement and seismic research in the Channel Islands area. Develop means for predicting, or at least detecting swiftly, the kinds of fault movement there that could repeat the monstrous sea waves that reportedly overran the Channel Coast in 1812.¹	NOAA*, Universities, USGS, CDMG
In designing dams down-drainage from possible volcanic mudflows or within potential ash fall region, consider possible ways to protect vulnerable parts (intakes, generators, valves) from potential volcanic debris. ¹	Dam building agencies: DWR, USCE, USBR, USFS, SCS, Power companies: PG & E, DWP, MWD, SCE	b. Distribution of seismic sea wave problems.	
D. ENABLING FUNCTIONS		i. Gather complete historic record of tsunamis and seiches that have been detected in California. Analyze historic and newly occurring seiches to determine probable recurrence rates of events of varying severity at vulnerable locations.²	NOAA*, USGS, Universities, DNOD, DWR
Produce handbook for planners and administrators to make them fully aware of volcanic hazards and their implications for land-use planning, and how to apply available geotechnical and other information on the subject. ¹	CDMG, USGS*	ii. Prepare tsunami/seiche hazard map of California, using historic data and bottom configuration analysis data.	CDMG
E. ENFORCEMENT FUNCTIONS (Not applicable)		Compilation scale program (1:250,000-1:1,000,000)	NOAA*, USGS, USCE, DNOD, CDMG
F. EMERGENCY-ACTION FUNCTIONS		Update, improve detail on CDMG map (1:1,000,000, July 1972; figure 6, this report).³	NOAA, USGS*, USCE, CDMG, DWR, DNOD, County consultants
Include volcanic hazards among the natural dangers considered by all emergency-action plans in areas that are potentially vulnerable to this threat. ¹	OEP, OES*, DCPA, USGS, CDMG, Cities, Counties, Utilities, Law enforcement (All agencies concerned with disaster planning)	County/regional scale program (1:62,500-1:125,000)	NOAA, USGS*, USCE, CDMG, DWR, DNOD, County consultants
G. OVERALL COGNIZANCE AND COORDINATION		Emphasize threats for which local government should prepare.³	NOAA, DWR, Local government* (consultants)
The status of volcanic hazards in California should be determined and reported upon annually by the appropriate State agency or agencies. Volcanic hazards should be included among the geologic hazards to be considered by the successor body to the GEC and JCSS after June 30, 1974 (Recommendation 26 in GEC, 1972, p. 55). ¹	USGS, CDMG*	Detail or quadrangle scale program (1:12,000-1:24,000)	
		Delineate in detail conditions of threat at those localities facing appreciable threat.¹	Local government (consultants)
IX. TSUNAMI HAZARDS		Project-scale mapping, for land-use permit decisions or construction purposes (1" = 100' to 1" = 1,000'). Delineate past and possible future runup areas, and depths. Indicate topographic factors that could divert waves and surges. Relate to expectable variations in tide and sea-state conditions.¹	
A. DATA DEVELOPMENT FUNCTIONS		e. Develop socio-economic information and analyses.	
1. Research programs to develop data on tsunamis.		i. Develop standard procedure, for local government use, for gathering complete and consistent socio-economic data on the costs of seismic sea waves, including costs of damage and of preventive or remedial measures.¹	Universities, NOAA, USGS, CIR*, DNOD, USCE
a. Research into geologic and seismic processes and bathymetric and coastal configurations that cause or affect seismic sea waves.		ii. Produce reliable statistical data on seismic sea-wave costs (per procedure 1-c-i above) both for past events, by analyzing historical data, and for each new event that occurs.¹	Local government, NOAA*, USGS, CDMG, DNOD, USCE
i. Investigate the geologic and seismic processes involved in the generation and transmission of seismic sea waves. Aim is to develop capability to reduce damage from them, and to improve capability to predict them.¹	NOAA*, USGS, ONR, Universities	d. Research into engineering response to tsunamis.	
ii. Survey and analyze the coastal shelf of California, to define and understand the relationship of bathymetric and coastal configurations to tsunami effects on the coastline. Analyze the relationship of local detail of bottom configuration to expectable local tsunami damage.¹	USCE, NOAA*, USGS, ONR, DNOD, Universities	i. Investigate behavior of waterfront structures, such as channels, breakwaters and seawalls, wharves, and mooring basins, in response to tsunami experience in California and elsewhere. Develop standards for "tsunami-proofing" typical waterfront structures.¹	AIA, USCE*, ICBO, DNOD, ASCE, ONR, USCQ
iii. Conduct field and laboratory investigations of seiche processes, and other wave-resonance phenomena to evaluate potential for seiche damage at vulnerable points of California's coast and interior lakes and reservoirs.¹	USCE, NOAA*, USGS, ONR, USBR, DWR, Universities	ii. Investigate means of preventing or controlling runup and other expectable sea-wave and seiche effects, or at least reducing damage, by building structures (e.g., seawalls, groins).²	USCE*, DNOD, DWR
iv. Establish a system of reliable tide gages specifically to detect and measure tsunami and seiche waves. Instruments must measure minor as well as major events and remain operable in calamitous events.¹	NOAA*, ONR, USCE, Universities	e. Event-study projects.	
		i. Whenever a tsunami causes damage to California, conduct detailed study of the nature of the wave itself, and its effects and damage to protective structures. Analyze the performance of utilitarian structures for their resistance to that event, and analyze wave-control structures for their effectiveness in reducing damage from that event.²	NOAA, USCE*, ASCE, Universities, ONR, USCQ, DNOD, AEG

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² Expansion of 1972 programs
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Recommended Programs	Recommended Agencies	Recommended Programs	Recommended Agencies
<p>ii. After event, analyze effectiveness of the event-study procedures, instrumentation, and other detection and response measures.²</p> <p>2. Information-dissemination programs</p> <p>a. Produce basic public information on tsunami processes and their importance for California. Aim for schools, government officials, and broad public audience. Include: What to expect from tsunamis and how to survive them.¹</p> <p>b. Devise clearinghouse and data-bank program for all information on seismic sea waves.²</p>	<p>All event-study agencies</p> <p>CDMO*, USGS, NOAA, USCG, DNOD</p> <p>NOAA* All tsunami information-producing agencies. All tsunami information-using agencies.</p>	<p>b. Produce model "Sea-wave hazard zone" ordinance, and procedure for enforcing it.¹</p> <p>c. Develop guidelines and interpretive information on the effects of sea-wave hazards on environmental impact decisions.¹</p> <p>E. ENFORCEMENT FUNCTIONS</p> <p>1. Executive and administrative control</p> <p>a. Apply appropriate safety principles in approving construction and use permits in areas subject to seismic sea waves.¹</p> <p>b. After a realistic deadline, require that specified actions to reduce tsunami losses be effectively taken by local jurisdictions in coastal areas before granting further funds to those jurisdictions for coastal studies, coastal planning and related activities.¹</p> <p>2. Operational inspection</p> <p>a. Inspect construction and other developments in locations subject to seismic sea wave hazards as necessary to assure compliance with safety regulations, and zoning, grading, and building ordinances.¹</p> <p>3. Insurance organizations should require evidence that seismic sea-wave dangers have been properly considered and loss-reduction measures taken before insuring structures in tsunami hazard areas.²</p> <p>4. Construction and development loans should not be approved for structures in tsunami hazard areas until lending institutions are assured that proper damage avoidance or prevention action will be taken.¹</p>	<p>OPR*, CIR, AIP</p> <p>OPR*, CIR, EPA, OIM</p> <p>Local government Planning commissions, City councils, Boards of Supervisors</p> <p>Funds-dispensing agencies: HUD*, CIR, NSF, ORP, OES</p> <p>Local government grading, foundation, and construction inspectors, Land-custody agencies, Utility agencies</p> <p>Insurance companies, Board of Underwriters</p> <p>FHA*, DVA*, Lending organizations</p>
<p>A. PLANNING FUNCTIONS</p> <p>1. Land-use planning</p> <p>a. Produce interpretive general-use manual to apprise planners of sea wave hazards in general, and of vulnerable localities in particular. Describe the potential dangers and possible land use planning actions to reduce losses, including standards for exclusion zones, permissible activities, and "tsunami-proof" construction. List the available maps, materials, and services, and describe their applications.¹</p> <p>b. Adopt standards and procedures for the land-use planning process that require adequate consideration of tsunami and seiche hazards. Revise general plans as necessary to incorporate effective model of seismic sea wave hazard element (within seismic safety element), employing current state of the art.¹</p> <p>2. Recovery planning</p> <p>Extend natural disaster insurance program to cover seismic sea wave damage.¹</p> <p>C. ENGINEERING FUNCTIONS</p> <p>1. If and when feasibility studies prove them to be desirable, build local sea-wave control structures (sea-walls, breakwaters, diversion levees) to stop or divert water surges, and reduce casualties and damage to onshore facilities and structures, and shipping.²</p> <p>2. Apply "tsunami-proof" design and construction principles to structures that need to be in zones threatened by sea watch so they can be removed or made impervious to tsunami damage on short notice.¹</p> <p>D. EMALING FUNCTIONS</p> <p>1. Political and administrative actions</p> <p>a. Provide authority and policy guidance. Adopt tsunami and seiche provisions in local government land-use plans (general plan) and adopt zoning and other ordinances and regulations necessary for implementation.²</p> <p>b. Provide resources. Approve funding and manpower to carry out inspections, reviews, and other actions required to accomplish the purposes of the plans, codes, ordinances and regulations.¹</p> <p>2. Coordinative, information guidelines</p> <p>a. Produce guidelines for treating sea-wave danger in the seismic safety element of general plans, including model language.¹</p>	<p>NOAA, USGS, AIP, CIR*, DNOD, CDMG (information)</p> <p>City and county planning departments, Regional government, Land-custody agencies: SLD, DPR, BLM</p> <p>DI*, FAIR, FIA*, Insurance industry</p> <p>USCE*, DNOD, Harbor and port districts</p> <p>USCE*, DNOD, Harbor and port districts, Shipping and sea-front industries</p> <p>City councils, Boards of Supervisors, Land-custody agencies, Utility agencies</p> <p>City councils, Boards of Supervisors, Land-custody agencies, Utility agencies</p> <p>CIR*, OPR, CDMG (information)</p>	<p>F. EMERGENCY-RESPONSE FUNCTION</p> <p>1. Provide overall guidelines and coordination to help local governments and land-custodial agencies cope with tsunami emergencies. Develop and disseminate guidelines for local governments and land-custody agencies on the use of the federal Seismic Sea Wave Warning System in disaster-readiness procedures. Include guidelines for tsunami preparedness measures.¹</p> <p>2. Develop contingency plans</p> <p>a. Include consideration of seismic sea wave and seiche hazards in emergency planning procedures of local governments, land-custody agencies, and public utility type agencies; produce elements of emergency response plans that properly prepare to cope with these hazards.¹</p> <p>b. Adopt emergency-response plans, and carry out the pre-event preparations called for therein.¹</p> <p>3. When tsunamis occur, activate contingency plans.²</p>	<p>NOAA, USGS, OEP, OES*, DCPA, AIP, AEG</p> <p>OES*, CIR, OPR, LCC, CSAC, Local government emergency-planning agencies: Police, Fire, Sheriff; Communications media, including private sector</p> <p>City councils, Boards of Supervisors, Land-custody agencies, Utility agencies</p> <p>All agencies</p>

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² Expansion of 1972 programs
³ Continue program at 1972 level

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Recommended Programs	Recommended Agencies
0. OVERALL COGNIZANCE AND COORDINATION FUNCTIONS	(body to be established)

The status of tsunami hazards in California should be determined and reported upon annually by the appropriate State agency or agencies. Tsunamis should be included among the geologic hazards to be considered by the successor body to the GEC and JCSS after June 30, 1974 (Recommendation 26 in GEC, 1972, p. 55).¹

X. SUBSIDENCE

A. DATA FUNCTIONS

1. Research programs to develop data on subsidence.

- a. Basic research into processes that cause or influence subsidence in California. Develop capacity to predict where and how severe subsidence will be under various types of use. Devise and improve ways to prevent subsidence, ameliorate damage from it, and to detect it in incipient stages.²

USGS*, DWR*, Universities, SCS, CDOG*, Oil and gas industry, Geothermal industry

- b. Map and describe areas of actual and potential subsidence in California.

USGS*, CDOG*, CDMG, SCS, DWR*

- i. Statewide compilation scale (1:250,000-1:1,000,000).³

DWR*, CDMG, USGS*

- ii. County/regional scale (1:62,500-1:125,000).³

CDMG, DWR*, USGS*, CDOG*

- iii. Detail or quadrangle scale especially in areas of groundwater withdrawal and potential hydrocompaction (1:12,000-1:24,000).³

DWR*, CDOG*, USGS*, SLD

2. Data-dissemination programs.

- a. Produce and disseminate educational information on subsidence for general public use, emphasizing regional and local occurrences.³

DWR*, CDMG, USGS, CDOG*, Education agencies, Mass media

- b. Establish clearinghouse and data-bank functions for all subsidence data and information of use in California.³

DWR*, CDMG, CDOG*, USGS, All data-producing agencies, All data-using agencies

a. Socio-economic analysis research.

Develop procedures and gather data, in consistent units and format, for evaluating losses due to subsidence, and the costs of loss-reduction measures. One aim is to determine where subsidence is actually damaging, and damage costs.¹

Universities (economics dept.), CDOG*, DWR*, USGS*, Cities, Counties, Land-estudy agencies

d. Research into engineering response to subsidence.

- i. Continue to investigate the response behavior of local surficial materials in subsidence-prone localities to various types of construction, so that structures can be located and designed to avoid damage.³

USGS*, DWR*, AEG, ICBO, ASCE, SEAOC

- ii. Investigate design and construction standards for foundations (including site preparation) and for structures to be placed in localities subject to subsidence, including public utility and industrial structures.³

ICBO*, ASCE, SEAOC

- a. Event-study research: Continue to investigate known subsidence situations, with the aim of determining the cost-effectiveness of loss-reduction measures.³

DWR*, USGS*, CDOG*, Oil and gas industry, ASCE, AEG, Universities

¹Essentially a new program
²Expansion of 1972 programs
³Continue program at 1972 level

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Recommended Programs

Recommended Agencies

B. PLANNING FUNCTIONS

1. Land-use planning.

Prepare handbook for planners, interpreting what is known of the process and local detail of subsidence in terms of its impact for land-use planning procedures. The handbook should develop effective procedures, including model language, for incorporating pertinent subsidence hazard information into the land-use planning procedures of local governments and land-estudy agencies. It should consider the subsidence threat in relation to use-capability of land, zoning procedures, and conditions to be imposed on development or use; in effect, incorporating subsidence consideration, when appropriate, into the geologic hazards considered in the preparation of safety elements of general plans.²

DWR, CDMG, USGS, OPR, CIE*, LCC, CSAC, CDOG, City and county planning departments

In areas undergoing, or subject to, subsidence, prepare or improve the provisions of general plans that deal with subsidence hazards.²

City and county planning departments

2. Recovery planning.

Develop procedure and practice of including subsidence among the geologic hazards covered under a natural disaster, broad-coverage insurance program.¹

FIA*, DI*

C. ENGINEERING FUNCTIONS

Specialized engineering works for dealing with subsidence include injection/represuring well systems at some oil or geothermal fields; sea-control dikes in some water front lowlands; special pilings, foundation extensions, and anti-submersion provisions for fixed activities in some coastal lowlands; special preparations necessary for developing spreading grounds for groundwater recharge; and canal-level adjustment provisions for some canal-route subsidence localities.

The agencies responsible for designing, constructing, and monitoring the performance of these structures should continue to review the effectiveness and feasibility of each installation and compare these factors with those for alternate methods of reducing subsidence losses, in terms of local costs and benefits, both short and long-term.³

DWR, CDOG, USBR, USCE, Cities, Counties, Special districts

D. EMERGENCY FUNCTIONS

Authority and responsibility for oil field and geothermal field-related subsidence are sufficient to deal with the problem, once it is recognized. Groundwater withdrawal subsidence is part of the major problem of groundwater basin management, which requires comprehensive concern for water quality and quantity. Except for water quality control efforts under the Porter-Cologne Act, controls on groundwater removal in California are exercised only by a few local governments without direct State control.

Hydrocompaction and peat soil subsidence, an essentially surficial problem, are coped with in various degrees by the owners of the local surface rights without direct control by government at any level.

E. ENFORCEMENT FUNCTIONS (Not applicable)

F. EMERGENCY-RESPONSE FUNCTIONS (Not applicable)

G. OVERALL COGNIZANCE AND COORDINATION FUNCTIONS

The status of subsidence problems in California should be determined and reported upon annually by the appropriate State agency or agencies. Subsidence should be included among the geologic hazards to be considered by the successor body to the GEC and JCSS after June 30, 1974 (Recommendation 26 in GEC, 1972, p. 55).¹

(body to be established)

¹Essentially a new program
²Expansion of 1972 programs

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The following are from Report to Congress: Disaster Preparedness by the Office of Emergency Preparedness, January 1972.

EARTHQUAKE

1. *The greatest potential for reducing the loss of life and property from earthquakes lies in restricting the use of land in high-risk areas and in imposing appropriate structural-engineering and materials standards upon both new and existing buildings.* The San Fernando earthquake demonstrated the value of the Field Act, since little damage, overall, was sustained by school buildings built to its specifications. However, it was also demonstrated that emergency and other essential facilities, such as hospitals, fire stations, police stations, and power plants, must be built to special safety standards in order to survive seismic disasters.

While primary action in these matters is required of State and local governments, the Federal Government can set an example through its own construction projects and

can make its financial assistance contingent upon State and local action. Also needed is a program to translate seismic risk factors into design standards to make new structures in high-risk areas earthquake resistant and to remove or improve structurally unsafe buildings. The approaches to this problem by the State of California and in the City of Long Beach are examples of a beginning to the solution to this problem.

2. *The greater use of instruments is essential to increasing knowledge, to providing risk maps, and to developing a theory of prediction—and perhaps control—of earthquakes.* In this connection, much can be learned in a general way from the atmospheric sciences, where extensive instrumentation has contributed to our knowledge and ability to predict, and in some instances modify, the weather.

3. *The development of seismic risk maps is an essential first step in hazard reduction and preparedness planning.* In all high-seismic zones, risk mapping of the faults near populated areas is needed in order to develop specific preparedness programs. It is most important that the results of risk mapping be produced in a simplified form for use by local government officials, planners, and engineers.

4. *At this time, the capability does not exist to predict the timing of earthquakes with any significant degree of certainty.* Indeed, the question of whether an earthquake prediction and warning capability can be developed is a point of contention among the experts. Nevertheless, there are some possibilities that deserve further close attention and concerted research and experimentation.

5. *There is a possibility that earthquakes can be controlled.* For example, experiments have shown that it is possible to induce the occurrence of small earthquakes, through the injection of fluids into faults, and thereby release the strain along a fault gradually, rather than letting it build up so that a massive earthquake results when the fault ruptures.

6. *The level of earthquake disaster planning in most areas of high seismic risk is not satisfactory.* A significant exception is in the San Francisco Bay area, where both the California Legislature and the Federal Government are taking important steps. The California Joint Committee on Seismic Safety is expected to produce a seismic safety plan in 4 years. At the Federal level, OEP's Outline Plan for Federal response to a possible earthquake in the San Francisco area and the OEP-NOAA study of what might happen in the event of an earthquake in that area will be prototypes for similar steps toward improving disaster preparedness. This combined vulnerability analysis and comprehensive planning by the Federal Government could also be a forerunner to State disaster planning envisioned in Section 206 of PL 91-606.

7. *The potential catastrophe of a major earthquake in a metropolitan area poses unique protection requirements.* In order to ensure the continued availability of vital utilities and services for recovery from the effects of an earthquake, several options should be analyzed: (1) feasibility of better protection for such services and facilities and their locations, (2) to the degree possible, relocation to less-vulnerable perimeter areas, and (3) development of backup systems. The studies mentioned above should be useful in this regard.

8. *Public awareness of the threat posed by earthquakes is essential to success in preparing for them and moderating their destructive effects.* Every possible means should be used to create and maintain this awareness: including coverage by the news media; the distribution in simple, convenient form of facts about earthquake hazards and emergency response check lists; and orientation and training sessions.

9. *The capability to mount effective search and rescue operations in an earthquake disaster is marginal.* As evident from the San Fernando case, there is a need for readily available special equipment and special procedures to locate and extricate buried persons.

FLOODING

1. Major flood control projects are, along with appropriate regulation of land use, the most effective means of making significant improvement in flood control. The statutory and regulatory process leading to construction of these projects now averages 18 years from the initial local request to the start of construction. Possible ways to reduce this developmental period are:

- Authorizing the Chief of Engineers to recommend surveys of major projects that appear to have a high potential for reducing flood losses;
- Revising the procedures for interagency coordination of the survey report to accelerate the coordination process;
- Increasing the \$10 million ceiling under which the Public Works Committees may authorize projects by resolution;
- Increasing the \$1 million limitation placed on the size of the projects that may be surveyed and recommended for funding by the Chief of Engineers under continuing authorities.

2. Effective regulation of land use is a major means of reducing flood losses. The flood plain management programs of the Corps of Engineers and the Department of Agriculture, which foster land-use regulation by local communities and development of action plans by River Basins Commissions should be pursued to permit communities to comply with the eligibility requirements of the National Flood Insurance Act. Similarly, the joint flood mapping program (Corps of Engineers, National Oceanic and Atmospheric Administration, and U.S. Geological Survey) should be emphasized, with a capability to permit production of maps on the scale of one inch to 400 feet (1"=400') for urban and urbanizing areas.

3. The Small Watershed Programs of the Department of Agriculture have not been adequately funded in past years. The funding level of the 1972 budget is, however, considered adequate. Adequate funding of these programs should be continued, to enhance the beneficial effects on flood abatement as well as on the environment.

4. Inadequate staffing of the River and Flood Forecast and Warning System of the National Weather Service results in a lack of flood forecast and warning service in some areas of the country and marginal service in others. Further, even where full service is available, it is not as timely as it could be because the River Forecast Centers normally have only a one-shift operational capability. Consideration should be given to staffing the River Forecast and Warning System as required to expand services to all geographical areas and to ensure that all River Forecast Centers can give extended hours of service when necessary.

5. The hydrologic data networks of the National Weather Service do not provide adequate coverage and rely mainly on manual reading and reporting of data. Data from many remote areas where floods originate are not available. Increased coverage and automation of the NWS hydrologic networks would ensure more complete and timely data and improve the accuracy and timeliness of flood forecasts. A complete network would be an expansion from 5,500 to 10,000 river and precipitation gauges, with 2,500 gauges automated through the NOAA Geostationary Operational Environmental Satellite (GOES) system and another 2,500 automated using ground communications.

6. Computer service available to some River Forecast Centers is inadequate. Two centers are without computer service and some others must rely on early-generation equipment with limited core memory and slow speed. An improved mathematical hydrologic forecast computer model is now being perfected and, coupled with modern computer systems, should increase the accuracy and timeliness of the forecasts.

7. Current methods for disseminating flood and flash flood forecasts are inadequate to insure positive warning of the general public. The National Weather Wire Service is not available to all areas of the country, and terminal equipment is too costly for many smaller communities and broadcast stations. Commercial telephone and telegraph, as the means to disseminate warnings to individual communities and broadcast stations, are slow and too time consuming for the Weather Service. Neither the National Weather Wire nor commercial wire directly reaches the general public.

The NOAA VHF/FM Radio Transmission service reaches only the limited public segment that has invested in receivers, and the receivers now in use do not have an automatic switch-on capability.

The warning system which a 1971 study, chaired by the Office of Telecommunications Policy, recommended for development and test could provide a capability for dissemination directly to the general public through a home warning device and could also offer an attractive alternative to the National Weather Wire Service. For this reason, extension of the Weather Wire Service should be considered in light of progress in development of this new system.

8. The flash flood prediction and warning program has a limited capability to provide technical assistance in establishing local community systems and lacks qualified personnel in many Weather Service Offices to prepare general forecasts of flash floods. Staffing of the National Weather Service should take into account the desirability of:

- Establishing a two-man flash flood team at each River Forecast Center to provide expertise for setting up community flash flood programs.
- Stationing flash flood prediction specialists at local Weather Service Offices serving areas vulnerable to flash floods.

9. Weather radar surveillance, and associated radar facsimile service, for local Weather Service Offices in many areas prone to flash floods can be significantly improved. Improvements in these aids for flash flood prediction would provide local Weather Service Offices with the capability to issue more definitive warnings and in many instances would obviate delays in ground observer reporting on location and intensity of rainfall. Consideration should be given to:

- Expanding the National Weather Service's radar network by some 25 radar stations and providing remote readout from selected Federal Aviation Administration radar facilities.
- Extending the National Weather Service's radar facsimile network (RAFAX) to local Weather Service Offices in areas vulnerable to flash floods and now without this service.

TSUNAMI

1. Accurate prediction of tsunami arrival time and wave height at any given point in the Pacific Ocean is not feasible at present. There is a need to reduce the time between detection of tsunami waves and the warning of vulnerable areas. Programs for improving prediction and warning, some already underway, include:

- The expansion and modernization of 28 seismographs and 84 tsunami sensors equipped with standardized instruments designed specifically for the detection of tsunamis to provide more complete and reliable information on the generation of tsunamis and on their amplitude and speed (NOAA plan).
- The use of NOAA's Geostationary Operational Environmental Satellite as a communication relay. This would reduce the elapsed time for warning to regional disseminating agencies from an average of 2-2½ hours to about 1 hour. This time saving would reduce the radius of the unwarned area from 1,000 to 400 miles.
- The establishment of a West Coast Regional Tsunami Warning Center, headquartered in San Francisco or Sacramento, to provide more timely warning service for nearly seven million people living in cities susceptible to tsunamis. Adequate warning of locally generated tsunamis cannot be assured from the centers in Honolulu or Palmer, Alaska.
- The initiation of a comprehensive research program to investigate (1) the geologic processes that deform the ocean floor and produce earthquakes, (2) the actual mechanism of tsunami generation, (3) the relationship between earthquake magnitude and tsunami height, (4) methods of tsunami recognition, and (5) methods for predicting wave heights and probable tsunami landfall.

2. The inclusion of tsunami emergency procedures in telephone directories, as done in Oahu, Hawaii, would improve the public response to tsunami warning. These procedures could include information on warning devices and emergency procedures, zones of possible inundation, evacuation routes, and the location of relief centers.

LANDSLIDES

1. Landslides do not represent a major danger to life or loss of property in the United States, except when they occur as secondary effects of earthquakes. Landslide-vulnerable areas are being identified through various Federal and State programs, with more concentrated effort going into areas where highways, railroads, reservoirs, and other extensive structures are located. In these cases, measures can be taken to mitigate the effects of landslides or even to avoid them, but predicting the precise timing of occurrence is not feasible. Additional basic information is needed from field and laboratory research on the causes and mechanics of landslides. This, in turn, could assist in predicting the time of their occurrence.

2. The existing landslide data have not been systematically analyzed to provide a national picture. However, in areas such as parts of California, where particularly hazardous slide conditions exist, the problem has been studied in detail and steps have been taken to minimize the effects. Land-use and construction regulations are potential means to further moderate the adverse effects of landslides.

3. Consideration should be given to expanding the landslide program of the U.S. Geological Survey, in conjunction with other Federal and State agencies, to encompass:

- Increased effort to identify and classify existing and potential landslide areas throughout the United States;
- Expansion of soil- and rock-mechanics research to develop information on the various basic types of landslides;
- Studies of elements which trigger landslides, such as earthquakes, blasting, change in hydrologic conditions, and heavy storms;
- Development of criteria for proper design methods and construction techniques to cope with landslide problems;
- Establishment of a central source of landslide information nationally.

FIRES

1. *The losses from fires can be reduced below the current annual average by emphasizing the existing prevention and presuppression programs by the Forest Service and the Bureau of Land Management.*

The following programs are in being and should receive continued emphasis:

- Construction of additional fuel breaks;
- Conversion of highly flammable woodland fuels to less volatile vegetation;
- Public education programs intended to reduce man-made fires;
- Early-season recruitment, training, and equipping of fire suppression forces;
- A developmental program for vegetative fuels disposal, other than prescribed burning.

2. *A major element of the fire suppression program is the air tanker fleet, which is fast approaching obsolescence. Losses from forest and grassland fires can only increase if deterioration of the tanker fleet is allowed to continue. Potential solutions to correct this situation include:*

- In the near-term period (10 years), the use of current military surplus aircraft—thus requiring smaller total expenditures, by the Federal Government as well as private operators, in maintaining an efficient aerial fire suppression capability.
- Waiver or amendment of present Defense Department policies to permit sale of the most suitable surplus military aircraft to private operators.
- Development by the Forest Service of a long-range plan to resolve the problem of future tanker obsolescence.

3. *The use of military aircraft equipped with a modular tanking capability would provide a valuable emergency backup force to the existing air tanker fleet.*

4. *Reduction of fire-igniting lightning, which causes 35 percent of forest and grass fires, is feasible. A research program, Project Skyfire, has been initiated by the Forest Service.*

5. *Aerial fire suppression is a key element of the initial attack team in accomplishing the ultimate goal of containing fires when they are small; however, additional operational evaluation is necessary to determine the most effective aerial suppression techniques. Project AERO-FIRE, a program of the Forest Service designed to develop these techniques, is now being funded.*

6. *Strengthening of fire prevention and suppression capabilities by State, local, and private interests will reduce loss of life and property. Options for improvement in these capabilities include these measures:*

- Close coordination by the Council of State Governments with State legislative bodies in the enactment and enforcement of improved fire laws.
- Provision, through preparedness planning, for the efficient use of available State resources in meeting fire emergency conditions. Plans should include specifics to resolve legal, technical, and fiscal problems relevant to the movement of personnel and equipment.
- Extension of rural fire control capability to cover rural lands now either unprotected or inadequately protected against fire.
- Provision of State contingency funds to permit the augmentation of established resources when extraordinary fire hazard conditions develop. Federal revenue sharing could be a source for such funds.

7. *The number of fires, from all causes, can be reduced or contained by an improvement in the present prediction and warning procedures. Programs which offer a potential for improvement are:*

- Completion by the Forest Service of the new National Fire Danger Rating System, with the dissemination and use of standardized procedures by all field agencies. Development of an "objective risk" rating system which would provide more accurate information of fire conditions in selected fire danger rating areas.
- Completion of the NOAA "Federal Plan for a National Fire Weather Service" to provide improved and expanded fire weather service for all fire control agencies.
- Standardization of procedures for fire reporting by pilots to FAA. A system similar to that of the Utah Cooperative Fire Fighters organization should be considered by the Forest Service, BLM, and FAA for use on a national basis.

BEACH EROSION

I. SOUTH CENTRAL REGIONAL COASTAL COMMISSION - GEOLOGY ELEMENT POLICIES, APRIL, 1974 (PROPOSED)

10. Minimal Interference with Natural Processes.

Works constructed to inhibit natural shoreline geologic processes (beach erosion, littoral drift, bluff retreat, and landslides) are often ineffective, unsightly, or result in unintended side effects and restrictions on shoreline use. Protective works that do not serve a general public function should not be constructed to inhibit these processes. In cases where protection of a public-serving facility is required, protective works should be minimal and designed to be unobtrusive and compatible with shoreline use.

a. Shoreline Processes:

The natural shoreline processes of erosion and deposition should not be interfered with due to the potential secondary effects of increased erosion, loss of beach and public and private investments. Shoreline erosion control structures should not be built unless a clear case of public benefit is demonstrated, structures or public investments are in danger of being eliminated, and the sand budget for the shoreline in that area is not negatively affected.

II. SOUTH CENTRAL REGIONAL COASTAL COMMISSION - LAND ELEMENT POLICIES, JUNE, 1974 (PROPOSED)

B. POLICIES:

1. Comprehensive Coastal Stream Management Program.

Because coastal streams provide many functions such as sand replenishment and anadromous fish habitat, and because the natural system and flood control-water conservation projects and beach sand replenishment programs are closely interrelated, regional in nature, and affect the entire California coastline, the planning and management of all new flood control-water diversion projects should be subject to review, modification, and approval, by the agency designated to implement the Coastal Zone Plan. In the public interest, the agency shall consider the environmental costs and benefits in addition to the

economic costs and benefits of each project within the watershed. Where applicable, projects shall provide for anadromous fish runs, a continual sand transport within the streams consistent with Policy No. 9c and d of the Geology Element, and preservation or replacement of any fish, wildlife, or valuable plant habitat affected by the project. Costs of such programs shall be borne by those landowners who will benefit by the project construction.

4. Replenishment of Beach Sands.

Because more than 95% of the sand on the Region's beaches comes from streams, anything that reduces stream velocity impairs beach replenishment. This includes water management devices that regulate stream flow and streambed settling ponds that act as sediment traps.

- a. If water management devices such as dams are considered necessary because of high intensity development in the flood plain, then the agency responsible for the flood control project shall also be responsible for maintaining sediment supply to the beach using some alternative mode of transport such as trucking, piping, or the use of conveyors.
- b. Open pits within the flood plains and currently being used by mining companies as water retention devices should be filled by the company when the site is evacuated. Until that time, any excess material dredged from the pit or reservoir shall remain available for down-stream transport during a flood flow, rather than be used as landfill.
- c. Because lagoons at the mouth of streams retard the movement of sediment from reaching the coast and because existing lagoons are valuable natural resources which would be impaired by additional sedimentation, the Coastal Commission or its successor agency shall investigate methods for sediment to bypass lagoons, thereby enabling such sediment to aid in beach sand replenishment.

II. SAN DIEGO REGIONAL COASTAL COMMISSION - GEOLOGY ELEMENT POLICIES, MAY, 1974 (PROPOSED)

POLICIES

1. State Agency to Administer Shoreline Management Program. Because there is a critical need to protect the shoreline from increasing erosion and because shoreline erosion problems often transcend regional boundaries, the State shall establish a strong and adequately funded comprehensive shoreline management program with planning, implementation and regulatory authority. This program shall be administered by an agency having a broad view of coastal land and water uses and shall be guided by the California Coastal Zone Conservation Plan. The agency shall rely on expertise including, but not limited to, physical oceanography, marine geology, engineering geology, structural engineering, and civil engineering in its operations.

2. Maintenance of Beach Sand Transport. Prior to the design and construction of dams, flood control projects, piers, groins, breakwaters, jetties, and other shoreline structures, thorough sediment transport studies shall be conducted to determine the impact of such projects on beach sand supply to affected beaches. Such structures shall be designed to ensure continued sand transport to and within the littoral cell and the project design agency shall be responsible for maintaining the continued transport of beach sand.
10. Shoreline Land Not Suitable for Development. Where it is determined, based upon thorough geologic study, by the local governmental agency having jurisdiction, that shoreline erosion or existing or potential landslides or probability of inundation render a shoreline site unsuitable for development, no buildings shall be permitted on such sites. If such sites are privately owned and if the owner approves, development rights or fee rights on such sites should be purchased through a state funded program administered by a state shoreline management agency. The costs to local government of the required geologic studies shall be reimbursed from the State General Fund.

IV. SAN DIEGO REGIONAL COASTAL COMMISSION - LAND ELEMENT POLICIES, JUNE, 1974 (PROPOSED)

B. Policies

1. Comprehensive Coastal Stream Review Agency. Because coastal streams perform many functions necessary for the preservation of the coastal environment, the use of and development within coastal stream flood plains shall be subject to review, modification and/or cancellation by the agency(ies) designated to implement the California Coastal Zone Plan. Examples of such uses subject to review include water management and flood control devices, streambed mining operations, and development within flood plains.
2. Comprehensive Coastal Stream Management Plan. Because the entire course of a stream from the head of the watershed to the coastline is a single system; and because the impacts of flood plain development, flood control projects, and water conservation projects are closely interrelated and regional in nature, an appropriate agency, with regional jurisdiction, shall be designated to comprehensively manage the coastal stream system.
The agency shall:
 - a) Determine the impact of mining operations on beach replenishment and identify locations where the impact would be minimal.
 - b) Investigate methods for sediment to bypass lagoons.
In a natural system lagoons eventually fill up with the sediment transported to the river mouth. Since this has a negative impact on beach replenishment and the lagoon ecology, artificial methods for allowing sediment to bypass lagoons should be developed. Because lagoons are an important part of the coastal stream system, the proposed lagoon management plan adopted in the Marine Element should be part of the Coastal Stream Management Plan.)

- c) Investigate specific streams to determine the potential for restoring anadromous fish habitats.
- d) Monitor sediment buildup behind dams.
- e) Prepare a management plan for each coastal stream which ensures continued beach replenishment.

V. VENTURA COUNTY PLANNING DEPARTMENT, VENTURA COUNTY COASTAL STUDY, ACCEPTED BY BOARD OF SUPERVISORS, JUNE, 1974.

Dunes & Beaches

The sloping beach and beach berm are the outer line of defense to absorb wave energy, and dunes are the last zone of defense in absorbing the energy of storm waves that succeed in overtapping the berm. In the continuing march to the sea, we have often ignored and destroyed this protection afforded by nature.

- POLICY That no construction should be permitted which would cause alterations in the sloping beach, beach berm or dunes without careful consideration of the effects onshore.

- POLICY That no sand should be removed from any sloping beach, beach berm or dune areas.

- POLICY That the removal of dune vegetation cover should not be permitted without replacement, since erosion and flattening of the dunes would occur.

- POLICY That consideration be given to the re-establishment, where possible, of dunes on beaches where the dunes have been removed, including the planting of dune vegetation.

Beach Zone

The beach zone is in a constant state of adjustment due to the action of waves, currents, and tides. With changes in the action of these agents seasonally and during storms, the shoreline changes its location, sometimes eroding or receding landward and at other times accreting or advancing seaward. Other longer-term cycles of erosion and accretion occur on shores, especially near inlets, in connection with the intermittent transfer of beach material across the inlet.¹²

- POLICY That no construction should be permitted which would cause changes in wave action or in movement of sand along the shore without careful consideration of the effects onshore.

- POLICY That the analysis of all flood control projects include a determination of the effects on beach sand supplies. The cost of approved projects should include the cost of replacing sand lost.

- POLICY That to deal with beach erosion back land and flood plain use management should be considered as an alternative to engineering measures.

- POLICY That beach erosion studies should concentrate on examining the causes of beach erosion and delineating specific levels of beach erosion hazard areas for use in land use decisions along the coast.

- POLICY That beaches and shorelines in general are unstable, as is shown by the migratory mean high tide line, and development proposals involving their use should be discouraged.

- POLICY That proposals involving use of the shoreline and coastal waters should be carefully examined in terms of sand supply and replenishment, and should be denied if interference with existing coastal processes is demonstrated.

- POLICY That sand, and supply of sand, is a valuable recreation resource and should be protected.

- POLICY That the effects of beach modification and construction near the mean high tide line are not fully understood, and proposals involving their construction and/or maintenance should be reviewed very closely.

- POLICY That proposed uses should be sited and designed in such a manner as to avoid possible public burden as well as loss of life and property in the event of natural hazards such as beach erosion or flooding.

● Issue: Beach Erosion - Last winter's storms and heavy wave action caused considerable beach erosion on Faria and Hobson County Beaches.

- RECOMMENDATION: If repair and corrective action is possible without disturbing other conditions, arrangements should proceed through coordinated efforts of the County, State and Army Corps of Engineers.

ADDITION

VENTURA COUNTY COASTAL STUDY

SPECIFIC RECOMMENDATIONS - Pages 67-68

Beach erosion Control and Beach Management Issues and Recommendations. Should Read: Further discussion with the County Public Works Department has indicated that both the expertise and the funding is available for further studies by staff, in the area of "sand budget" and "sand availability" related to any particular project under discussion, now or in the future. Inasmuch as Public Works possesses the capability to undertake much studies, they should persist in making determinations of imports, and recommendations for change.

It is, therefore, recommended that Public Works set up a program utilizing the expertise and fundings, involving other related agencies, and indicating how beach erosion and sand management problems will be worked out.

V. U.S. ARMY CORPS OF ENGINEERS, SHORE PROTECTION GUIDELINES, 1971

Sand is a rapidly diminishing natural resource. Although once carried to our shores in abundant supply by streams, rivers and glaciers, cultural development in the watershed areas has progressed to a stage where large areas of our coast now receive little or no sand through natural geological processes. Continued cultural development by man in inland areas tends to further reduce erosion of the upland with resulting reduction in sand supply to the shore. It thus becomes apparent that sand must be conserved. This does not mean local hoarding of beach sand at the expense of adjoining areas, but rather the elimination of wasteful practices and the prevention of losses from the shore zone whenever feasible.

VI. STATE OF CALIFORNIA DEPARTMENT OF PARKS AND RECREATION, CALIFORNIA COASTLINE PRESERVATION AND RECREATION PLAN, 1971

Local government must continue to assume the primary responsibility for protecting the quality of the environment. *This will require firm stands by local planning commissions and legislative bodies. Developments should be set back from beach and bluff lines, and should not be allowed to obscure views of long stretches of the coast. These set backs should be especially generous where shoreline erosion is a problem.*

VII. VENTURA COUNTY PLANNING COMMISSION, SHORELINE
DEVELOPMENT MASTER PLAN, 1956

19. The water conservation projects are recognized, of course, as matters of prime necessity. All that can be said at this point is to stress the necessity of watching beach conditions in the Oxnard Plain very closely after the Sespe and Piru Creek dams have been built. If the beaches then suffer depletion, erosion will have been begun and the entire Oxnard Plain itself will be threatened. In such an eventuality the problem of protection against beach erosion will have to be approached with other methods.

LIQUEFACTION

These are the recommendations of the U. S. Geological Survey included in Geological Survey Circular 690 by D. R. Nichols and J. M. Buchanan-Banks, Seismic Hazards and Land Use Planning:

GROUND FAILURE

IMPLICATIONS FOR PLANNING AND LAND-USE CONTROLS

General land-use policy might be guided partly by knowledge of broad areas where instability is believed to be so pervasive that, along with other considerations, its preservation as open space or other nonoccupancy, may be indicated. On the other hand, except during earthquakes, such failures generally occur fairly slowly, may be preceded by indicators, and usually do not result in loss of life, even though extensive or complete destruction of property is common. Therefore, the problem might be ignored. Alternatively, since ground failures can be life hazards during earthquakes, areas of known or likely low stability might be designated as geologic hazard zones. In such zones background studies (geologic and soil engineering reports) should be required to demonstrate that both static and dynamic hazardous conditions either do not exist or can be overcome by site preparation work or engineering design prior to approval of subdivision and site development applications. Although individual structures may be sited safely in such areas, roads, gas, water, and sewer lines can seldom be built without crossing unstable areas. Long-term costs in the form of public services may be great and generally must be borne by the entire community.

Other solutions to instability problems that are being pursued include adoption of a program to allow tax deductions for property owners whose land is particularly susceptible to ground failure. Such a program might be designed to alleviate tax burdens on property where existing structures are being damaged and on unimproved land as long as it remains unimproved or until the owner can demonstrate that he has eliminated the hazardous conditions. For those relatively few developed areas where severe instability problems are known to exist and disaster merely awaits the triggering action of an earthquake or an exceptionally wet winter, consideration should be given to the implementation of a hazardous building abatement ordinance or the initiation of nonconforming use procedures.

STRUCTURAL DEFICIENCIES

Source: Meeting the Earthquake Challenge

Final Report to the Legislature

State of California by the Joint

Committee on Seismic Safety

January 1974

Abatement of Hazardous Structures: A Two-Phase Program

Older structures in this State constitute one of the major hazards to life and property because, for the most part, they were not designed to be earthquake resistant. The existing huge inventory of such buildings means that the abatement problem is complicated and its solution costly. Hazard-abatement policies will have to be worked out carefully, with full consideration of their social and economic impact, and other possible consequences. Programs of hazard reduction will have to be scheduled according to a realistic timetable, employing priority systems based on expert evaluation of hazard levels...

1. First Phase: Eliminating the Most Hazardous Buildings

a. Government should require that every building meeting all of the following criteria be inspected, and that after review and analysis, any such building found deficient should be reinforced or demolished no later than six months after the deficiency finding is final:

1) The building was constructed before 1933, or a later designated date. Later dates may be established for specific local jurisdictions, based on an evaluation of each jurisdiction's history with respect to design standards and effectiveness of enforcement. This should probably be done by the proposed State commission on seismic safety.

2) The building lies within a zone designated as probably subject to substantial earthquake shaking. To facilitate administering the hazards reduction program, the zone areas should conform to existing governmental boundaries, and avoid bisecting individual local jurisdictions.

3) The building is of "Type III" construction with load-bearing unreinforced masonry walls using lime mortar, and wood floors and roof.

b. Priorities of building inspection and reviews should be assigned on a block-by-block basis, with buildings of greatest occupancy density receiving highest priority, other factors being equal.

c. A hearing process should be established to facilitate expeditious hazard-abatement proceedings, as well as to guarantee fairness and due process.

d. Building occupancy levels should be considered in making decisions on the priority of abatement. Thus certain high-hazard buildings might be allowed to remain, if only low occupancy levels were involved. Dangerous buildings permitted to remain should be posted with signs clearly stating the degrees of hazard.

e. Special precautions should be taken to insure that occupancy levels in hazardous buildings are not increased.

f. Buildings of historical significance - and that have low occupancy levels - as determined by the appropriate local jurisdiction may also be exempted from hazard abatement procedures.

2. Second Phase: Taking Stock of Less Hazardous Buildings

In the second phase of the program, less hazardous buildings should be identified, or estimates made of their prevalence, location, and degree of hazard posed. This could be done on the basis of existing data, or on the basis of field sampling by competent engineers. The information thus obtained should, in turn, make it possible to estimate the magnitude and cost of the task of hazard reduction, including the number and kinds of personnel needed to carry it out. These estimates would make it possible to carry out the program in realistic stages over a period of many years. The program should also include specific recommendations for financing all of the work that will have to be done.

The following is from

THE SEISMIC SAFETY STUDY for the General Plan

A report by the Tri-Cities
Citizens Advisory Committee on
Seismic Safety to the Cities of El Cerrito,
Richmond, and San Pablo on Earthquake Hazards
and Recommended Measures to reduce those Hazards.

September 1, 1973

STRUCTURAL ENGINEER'S RECOMMENDATIONS
FOR STRUCTURAL HAZARD REDUCTION

As a result of this study, we can make a series of recommendations for the reduction of earthquake hazards in both existing and new construction. Listed in the priority that we would suggest, they are as follows:

1. Adopt a "parapet" ordinance whereby the existing hazardous parapets must be eliminated or reinforced. This is probably the greatest single cause of life loss in previous American earthquakes and can be instituted with few economic repercussions to the community. The enforcement of such an ordinance should be phased so that areas of high traffic would be corrected first.
2. Perform a more detailed and thorough investigation of all fire stations in the study area including their geological setting. In the section on Fire-houses, we note that 6 out of 14 firehouses may have serious deficiencies and may not be operable after an earthquake. Any review should include access roads, utilities, etc.
3. Perform preliminary, but thorough investigation on all of the older public buildings that are essential to relief and emergency operations after a disaster.
4. As required by State Law, replace or reinforce any schools that do not conform to the requirements of the Field Act. Concurrently, review in more detail those schools that are on or near suspected poor foundation materials even though they technically meet the requirements of the Field Act. Subsequently, even the Field Act Schools should have a general review to determine the "minor" hazards of light fixtures, falling ceilings, arcades, book shelves and furniture, etc. If warranted, precautionary measures can be taken then to reduce the effects of those hazards.
5. Adopt the provisions of the 1973 Uniform Building Code when it is available. Examine those provisions to see if Section 2518(f)5 have been corrected. If not, they should be corrected in the new adoptions.
6. Provide for some program of eliminating the so-called "dangerous buildings" - at least the old poorly tied together buildings. This will require some local legislation. Any program should be phased to reduce hardship. Some tax incentives could help this program get started and move faster.
7. Encourage the utilities to continue to participate

in conferences and research on measures to reduce hazard due to utilities in ground that is unstable for various reasons. While they have adopted and are using the best practices now known, this is a field that is receiving considerable study and research due to the failures in the San Fernando earthquake. When better and more reliable methods are found, provide the proper incentives to encourage their use promptly.

8. Review in more detail the situation of apartment houses on concrete stilts (to provide parking) in the light of present knowledge of performance of concrete moment frames in earthquakes. It is entirely possible that a little preventive work now will greatly reduce damage and some hazard in future earthquakes. At present we would not recommend a mandatory program based on legislation, but if the risk is there, we believe many owners and occupants would act if they were informed of the facts.
9. Discuss with the industrial community the probable effects of ground liquefaction on their operations to see if some reasonable method of reducing the consequential effects can be found. While the loss of an isolated or a few industrial plant operations may have little overall effect on the community, damage to a large proportion will have very large repercussions whose impact should be studied and discussed before the event.

FIRE

The California Department of Conservation's Task Force on California's Wildland Fire Problem's Recommendations:

In the area of Fire Prevention, the Task Force recommends that we must:

- A1. Provide fire protection standards for local governments to use in preparing the safety element of their general plans.
- A2. Devise a formalized "Wildland Fire Hazard Alert" system for alerting and activating wildland fire protection agencies whenever critical fire weather is predicted..
- A3. Help solve the incendiarism problem by improving present law enforcement and investigation equipment, adapting equipment available in other fields, and developing new equipment where needed.
- A4. Enlist the aid of courts, prosecuting attorneys, and the general public to make present laws more effective in dealing with the problems of illegal use of fire and fire-causing practices.
- A5. Suspend all debris burning operations and alert the public to the potential risk for wildfire from any cause during critical fire weather.
- A6. Curtail all off-the-road use of machines and mechanical or power-driven equipment during critical fire weather.
- A7. Provide fire prevention personnel in numbers that are adequate to properly inspect wildland structures and activities and to make personal contacts with wildland residents and other users, especially during critical fire weather.
- A8. Intensify mobile fire prevention patrols immediately before and during critical fire weather.
- A9. Improve power line inspections.
- A10. Urge all power utility companies to institute special operating instructions for their field personnel during critical fire weather.
- A11. Request all power utility companies to make underground installations of relatively low voltage transmission and distribution lines in high fire hazardous areas.
- A12. Determine the specific causes and locations of roadside fires.
- A13. Establish an ad hoc Fire Prevention Action Committee to coordinate implementation of these fire prevention recommendations.

In the area of Fuel Management and Hazard Reduction, the Task Force recommends that we must:

- B1. Prepare hazard reduction standards for wildland subdivisions.
- B2. Encourage land management agencies to use prescribed burning techniques to selectively reduce fuel hazards consistent with management objectives and laws and with due concern for environmental quality.
- B3. Provide standards for locating and constructing fuelbreaks and greenbelts.
- B4. Increase the number of men available for building fuelbreaks and other fire control facilities.
- B5. Urge fire prevention organizations to give increased emphasis to fuel management and fuel hazard reduction.
- B6. Investigate current insurance practices covering prescribed burning operations on privately owned wildlands and determine the fiscal liability of private individuals for costs of suppression and damages in the event of the escape of a prescribed fire.

- B7. Determine the legal responsibility of public fire protection agencies for fuel hazard reduction on private lands.
- B8. Demonstrate fuel management techniques in high fire hazardous areas.
- B9. Implement fuel management programs in the California State Park and Recreation System for fire prevention and hazard reduction purposes.
- B10. Urge county road departments to implement fuel hazard reduction programs for all county-maintained roads located in high fire hazardous areas.
- B11. Strengthen legal requirements for clearance of hazardous wildland fuels adjacent to structures beyond property lines.
- B12. Strengthen research and action programs related to "fire resistant" plants.
- B13. Find new ways of controlling brush growth.
- B14. Synthesize and summarize all fuel management and hazard reduction information for all wildland vegetative types in California and recommend action programs for each type.
- B15. Establish an ad hoc Fuel Management and Hazard Reduction Action Committee to coordinate implementation of these fuel management and hazard reduction recommendations.

In the area of Zoning, Subdivision Codes and Land Use, the Task Force recommends that we must:

- C1. Provide guidance and technical assistance to local governments in their efforts to integrate a wildland fire protection element into their general plans.
- C2. Provide local governmental planning professionals an environmental resource data system and consulting assistance in natural resource protection and management fields.
- C3. Require local government to consider land use capability in terms of fire and other natural hazards.
- C4. Strengthen the State Planning Law to provide for better wildland use regulations and better fire protection, particularly in regards to "lot splitting" in fire hazardous wildlands.
- C5. Make land developers responsible for providing a fuel management program consistent with wildland fire protection requirements in the interim period between individual lot sales and residence construction.
- C6. Require that firefighting equipment be provided access to water contained in all privately-owned swimming pools located in or adjacent to the wildlands for onsite fire protection.
- C7. Establish an ad hoc Fire Protection in Land Use Planning Action Committee to coordinate implementation of these zoning, subdivision codes, and land use recommendations.

In the area of Building Codes and Construction Material Requirements, the Task Force recommends that we must:

- D1. Offer to local governments standards for building location and density in the wildlands.
- D2. Require that all buildings constructed in high fire hazardous wildland areas comply with specifications in six specific areas of concern to reduce the chances of wildfire spreading from burning wildland vegetation to the buildings.
- D3. Develop standards for numbering buildings located in the wildlands.
- D4. Establish an ad hoc Building Construction Action Committee to coordinate implementation of these building code and construction material requirements recommendations.

In the area of Fire Control, the Task Force recommends that we must:

- E1. Develop a fire command structure for controlling fire suppression operations on conflagrations spreading through the jurisdictions of several fire protection agencies.
- E2. Update the Federal Rural Fire Defense Plan to recognize recent changes in state and federal wildland fire protection legislation.
- E3. Update the State Fire Disaster Plan to recognize changing needs and new legislation related to the Office of Emergency Services.
- E4. Improve firefighting communications systems to meet multi-agency needs, especially during large fire situations.
- E5. Develop new equipment and techniques to increase the effectiveness of the individual firefighter or to replace manpower.
- E6. Develop and test new techniques to improve the tactical use of organized firefighting forces, including the use of the modular "Task Force."
- E7. Improve the utility of state and federal military forces on conflagration fires.
- E8. Provide standards for road construction in the wildlands adequate for fire protection requirements.
- E9. Develop standards for water supply required for fire protection in the wildlands.
- E10. Establish an ad hoc Fire Control Action Committee to coordinate implementation of these fire control recommendations.

RECOMMENDATIONS

The following recommendations are offered for consideration and adoption by the Board of Supervisors either acting on behalf of county government or on behalf of the Special Districts for which the Board acts as the governing board. It is recommended that:

GENERAL

1. The Board of Supervisors adopt the Seismic Safety and Safety Elements.
2. The Board of Supervisors certify the Negative Declaration for the Seismic Safety and Safety Elements.
3. In the review of proposed vital structures (such as: hospitals, schools, public services and buildings) and critical facilities (such as: power plants and water works) and facilities that could provide a substantial threat to the population (such as oil storage facilities) county staffs when applicable be instructed to require of developers any necessary information relative to hazardous conditions which may affect their proposal, and further require the developer to specify the actions intended to alleviate identified hazards.
4. All agencies involved in warning and evacuation activities be instructed to periodically review and update, if necessary, their plans and procedures in light of the hazards defined and described in these elements or any future studies.
5. The Board of Supervisors support the concept of uniform development standards and encourage county staffs to coordinate on a continuing basis with all entities within the county in the creation of such standards.
6. The Board of Supervisors direct staffs to pursue, when appropriate, further investigation of the significant hazards affecting the county, and that these investigations be done in cooperation with the other jurisdictions in the county.

FAULT DISPLACEMENT

7. The Board of Supervisors direct county staff to develop a proposal for submittal during the 75-76 budgetary process outlining the feasibility of preparing the necessary ordinances to implement

the modified policies and criteria of the State Mining and Geology Board, in the administration of Fault Displacement Special Studies Zones, as shown on Hazard Plate I. (see Option 13, page II-33)

GROUND SHAKING

8. The Board of Supervisors direct staff to pursue, when feasible, the compilation of more complete data concerning the ground shaking hazard. In the interim, the Board adopt the Hazard Zones as designated on Hazard Plate II and direct staff to utilize them for regional and local plans and special studies, and to guide future investigations of the hazard.

FLOODING

9. The Board of Supervisors direct staff to investigate and develop when appropriate, any necessary ordinances to implement the National Flood Insurance Act and to maintain the county's eligibility for National Flood Insurance.

LANDSLIDE/MUDSLIDE

10. The Board of Supervisors direct the County Planning Division to develop a proposal for submittal during the '76-'76 budgetary process outlining the feasibility of preparing a Hillside Development Ordinance.
11. The Board of Supervisors adopt the Hazard Zones as designated in Hazard Plate IV and designate staff to utilize them for regional and local plans and special studies, and to guide future investigations of the hazard.

BEACH EROSION

12. The Board of Supervisors direct all applicable agencies to:
 - a. carefully consider any proposals for direct alteration of shoreline configurations, or structures which protrude into the ocean, including groins, jetties, seawalls and breakwaters; in order to determine the impacts and, if feasible, avoid or rectify said impacts.
 - b. give consideration in the design of necessary flood control/water retention structures, such as dams and debris basins, to the potential effects of sand retention and other related impacts.

These considerations should take into account the cumulative impacts of proposals and should be accomplished before substantial financial commitments are made.

13. The Board of Supervisors direct the Public Works Agency to consider in its proposed beach management program and encourage the Corps of Engineers to consider in its 1978 Shoreline Study the following items:
- a. the evaluation of the impacts of riverbed mining operations upon sediment transfer.
 - b. the development of programs for the preservation and or stabilization of existing sand dunes, and the construction of artificial dunes where appropriate.
 - c. the development of standards to be utilized in the prevention of property damage in beach erosiveness.
 - d. the more thorough and specific definition of known beach erosion zones.
 - e. the development of a program to monitor shoreline fluctuations on a continuing basis in order to estimate current erosion, as well as establish baseline data for future studies.

AIRCRAFT ACCIDENTS

14. The Board of Supervisors authorize Planning staff to draft interim land use guidelines relative to near-airport Hazard Zones as designated on Hazard Plate IV. Such guidelines, once adopted, shall remain in effect until such time as new guidelines are promulgated as a result of the Ventura County-Oxnard Airport Redevelopment Plan.

LIQUEFACTION

15. The Board of Supervisors direct staff to pursue, when feasible, the compilation of more complete data concerning the liquefaction hazard. In the interim, the Board adopt the Hazard Zones as designated on Hazard Plate V and directs staff to utilize them for regional and local plans and special studies, and to guide future investigations of the hazard.

TSUNAMI

16. The Board of Supervisors direct the Sheriff's Department and the Office of Disaster Services to review and update if necessary, the County Basic Plan. The Board further directs that the name of this plan be changed to: Basic Plan - Seismic Sea Wave Warning - Evacuation.
17. The Board of Supervisors adopt the Hazard Zone on Hazard Plate V and direct staff to utilize it for

study purposes. The Board further directs the replacement of the present warning area map in the County Basic Plan with the adopted hazard zone.

SEICHE

18. The Board of Supervisors adopt the Hazard Zone as designated in the Seiche hazard chapter of the Seismic and Safety Element and direct staff to utilize them for regional and local plans and special studies, and to guide future investigations of the hazard.

SUBSIDENCE

19. The Board of Supervisors support the ongoing Southern California Cooperative Level Network Program participation by the County Surveyor and direct the Planning Division to modify the present hazard zones as the leveling program progresses. In the interim, the Board adopts the Hazard Zones as designated on Hazard Plate VI and instructs staff to utilize them for regional and local plans and special studies and to guide any future investigations of the hazard.

EXPANSIVE SOILS

20. The Board of Supervisors continue to support the existing regulations and programs which are adequately dealing with the hazard. That the state of the art be continuously monitored and that existing regulations and programs be modified as conditions warrant.

FIRE HAZARD

21. The Board of Supervisors direct the Planning Division to prepare a proposal for submittal during the '75-'76 budgetary process outlining the feasibility of conducting a detailed study of fire hazard areas, based upon criteria in the National Fire Danger Rating System. This study should be undertaken in cooperation with the U.S. Forest Service and the County Fire Protection District, and should be used if applicable to identify areas to be given priority in future fuel management programs.
22. The Board of Supervisors support the Los Padres National Forest controlled burn program as a wildfire prevention tool, along with fuelbreaks and other fire prevention measures.

STRUCTURAL DEFICIENCIES

23. The Board of Supervisors direct the Building and Safety Division of the Environmental Resource Agency to prepare a proposal for submittal during the '75-'76 budgetary process outlining the feasibility of a program to evaluate

existing vital and critical facilities for their conformance to the Uniform Building Code and at the completion of that program report back with priorities for upgrading of any structural deficiencies discovered.

APPENDIX

APPENDIX I

An attempt has been made to define all technical words contained in the text. If a technical word is not defined, often the word can be found in a standard dictionary. In using the glossary, the reader will note that many technical words appear within the definitions themselves. Definitions of these words can also be found in the glossary.

Active faults. Active faults are faults which show evidence of any or all of the following:

1. Topographic or physiographic expressions suggestive of geologically young fault movements.
2. Fault creep.
3. Records of surface rupture within or adjacent to the study area in historic time.

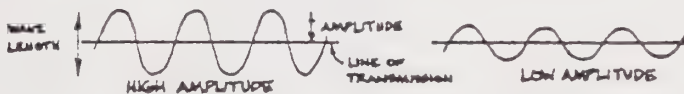
Aggregate. Materials such as sand, gravel, and crushed rock, with which cement or bituminous material is mixed to make concrete or asphalt.

Alluvial fans. Alluvial fans are built by rivers flowing from mountains onto lowlands. They are low cone-shaped heaps, steepest near the mouth of the valley, and sloping gently outward with ever decreasing slope.

Alluvium. A general term for the sediments laid down in river beds, flood plains, lakes, fans at the foot of the mountain slopes, and estuaries during relatively recent geologic times.

Amplification. The increase in earthquake ground motion that may occur to the principal components of seismic waves as they enter and pass through different earth materials.

Amplitude. One-half the elevation of the crest of a wave or ripple above the adjacent troughs:



Anomaly. A deviation or inconsistency of a specific land feature from uniformity with the larger area.

Anomalous features. See "anomaly".

Anticline. An upfold or arch of rock strata formed by internal earth pressure forming a shape like the roof of a house. Erosion could alter this shape leaving only the inclined strata.

Attitude (of rock structures). A term including the terms dip and strike. The attitude of the flat surface of a sedimentary bed, whether inclined or not, is referred to the horizontal plane. Dip is its slope inclination (in degrees) from this plane, and is measured with a clinometer. Strike is the compass bearing on the line of intersection of its surface with horizontal plane. The terms may also apply to faults, veins, and dikes.



Basalt. A dark-colored, fine-grained volcanic rock, composed essentially of the mineral plagioclase feldspar and one or more dark minerals such as pyroxene.

Bed. The smallest division of a stratified series, and marked by a more or less well-defined plane from its neighbors above and below.

Bedding plane. In sedimentary or stratified rocks, the division planes which separate the individual layers, beds or strata.

Bedrock. Any solid rock underlying soil, sand, clay, etc.

Berkeley hills. The hills on the immediate east side of San Francisco Bay contained within such cities as Oakland, Berkeley, El Cerrito and Richmond.

Bore hole. A hole drilled into the earth for exploratory purposes.

Breccia. A rock composed of angular coarse fragments, commonly cemented together.

Chert. A compact sedimentary rock containing abundant quartz of organic or precipitated origin.

Clastic rock or Clast. A rock which is composed principally of detritus transported mechanically into its place of deposition.

Cohesion, rock. The capacity of a rock to stick or adhere together. In effect the cohesion of soil or rock is that part of its shear strength which does not depend upon interparticle friction.

Cohesive materials. See "cohesion, rock".

Colluvium. Soil deposited by soil creep, landslides and surface wash.

Compaction. Decrease in volume of sediments, as a result of compression of sediments deposited above them.

Competent beds. Those beds or strata which, because of massiveness or inherent strength, are able to lift not only their own weight but also overlying rock. Therefore, such rock material is especially able to withstand failure such as landsliding.

Conglomerate. A rock composed of larger fragments (such as pebbles or cobbles) set in a matrix of finer material (such as sand, silt, and/or clay).

Consolidated material. Soft or hard rock which requires some medium of loosening at the excavation site before it can be handled. The more loosening required (i.e., blasting as opposed to bulldozing) the more consolidated the material.

Continental rock. A rock unit laid down on land as opposed to one laid down in marine water.

Contra Costa Group. The type of poorly consolidated young sedimentary rock found in the Tri-Cities Area east & north of the Berkeley hills ridgeline.

Creep, fault. See "fault creep".

Cross bedding. The arrangement of narrow layers of sedimentary rock such that layers are at angles to rather than parallel to the other layers.

Damping. A resistance to vibration that causes a progressive reduction of motion with time or distance.

Deformation of rocks. A change in the original form or volume of rock masses produced by faulting, folding or other tectonic forces.

* From "The Seismic Safety Study," (A joint planning study of the Cities of El Cerrito, Richmond and San Pablo, Calif.)

<u>Detritus.</u>	The materials that result from the breaking up, disintegration and wearing away of minerals and rocks resulting in alluvial deposits.	<u>Fault trace.</u>	The intersection of a fault and the earth's surface as revealed by dislocation of fences, roads, by ridges and furrows in the ground, etc.
<u>Diatomite.</u>	A light friable, siliceous material chiefly produced from the remains of minute forms of algae.	<u>Fault zone.</u>	A fault instead of being a single clean fracture, may be a zone hundreds or thousands of feet wide; the fault zone consists of numerous interlacing small faults or a confused zone of gouge, breccia or other material.
<u>Differential Settlement.</u>	Loss of strength or the loss of water and sand through liquefaction often does not occur evenly over broad areas. Thus the ground settles different amounts in adjacent spots. Can be very destructive to buildings.	<u>Fault, active.</u>	See "active fault".
<u>Dip.</u>	See "attitude".	<u>Fault, inactive.</u>	See "inactive fault".
<u>Dip slip.</u>	Fault displacement parallel to the dip of the fault. See "attitude" and "slip".	<u>Fault, normal.</u>	See "normal fault".
<u>Displacement.</u>	The dislocation of one side of a fault relative to the other side resulting from fault movement.	<u>Fault, reverse.</u>	See "reverse fault".
<u>Earth-flow.</u>	A slow flow of earth lubricated with water. Earth-flows may be discriminated from earth-slumps by reason of their greater mobility.	<u>Fault, right-lateral.</u>	See "right-lateral fault".
<u>Earthquake.</u>	Perceptible trembling to violent shaking of the ground, produced by sudden displacement of rocks below and at the earth's surface.	<u>Fault, thrust.</u>	See "thrust fault".
<u>Earthquake focus.</u>	See "focus".	<u>Faulting.</u>	The movement which produces relative displacement of adjacent rock masses along a fracture.
<u>Earth-slump.</u>	See "earth-flow".	<u>Fissure.</u>	An extensive crack, break, or fracture in the rocks.
<u>Elastic limit.</u>	The maximum stress that a material can withstand without undergoing permanent deformation either by solid flow or by rupture.	<u>Flexuring.</u>	Synonymous with folding.
<u>Elasticity.</u>	The property or quality of being elastic, that is, an elastic body returns to its original form or condition after a displacing force is removed.	<u>Focal depth.</u>	Depth of an earthquake focus below the ground surface.
<u>Eocene.</u>	An epoch of the lower Tertiary period. It ranges from 37 to 38 million to 53 to 54 million years before the present.	<u>Focus.</u>	The point within the earth which marks the origin of the elastic waves of an earthquake.
<u>Epicenter.</u>	The geographical location of the point on the surface of the earth that is vertically above the earthquake focus.	<u>Fold.</u>	A bend in rock strata.
<u>Fan, alluvial.</u>	See "alluvial fan".	<u>Formation.</u>	A rock body or an assemblage of rocks which have some character in common; applied to a particular sequence of rocks formed during one epoch; a rock unit used in mapping.
<u>Fault.</u>	An earth fracture or zone of fracture along which the rocks on one side have been displaced in relation to those of the other.	<u>Fracture.</u>	Breaks in rocks due to intense faulting or folding.
<u>Fault block.</u>	A body of rock bounded by one or more faults.	<u>Free face.</u>	A sloping surface exposed to air or water such that there is little or no resistance to lateral movement of earth materials.
<u>Fault creep.</u>	Very slow periodic or episodic movement along a fault trace unaccompanied by quakes.	<u>Frequency.</u>	The number of seismic wave peaks which pass through a point in the ground in a unit of time. Usually measured in cycles per second.
<u>Fault-scarp.</u>	The cliff formed by a fault. Most fault scarps have been modified by erosion since faulting.	<u>Friable.</u>	A term applied to rocks that are easily crumbled or pulverized.
<u>Fault set.</u>	Two or more parallel faults within an area.	<u>Geodetic measurements.</u>	Controls on location (vertical & horizontal) of positions on the earth's surface of a high order of accuracy, usually extended over large areas for surveying and mapping operations.
<u>Fault slip or slippage.</u>	The relative displacement of formerly adjacent points on opposite sides of a fault. Also known as fault creep.	<u>Geology.</u>	The science which treats of the earth, the rocks of which it is composed, and the changes which it has undergone or is undergoing.
<u>Fault system.</u>	Two or more fault sets formed at the same time.	<u>Geophysical surveys.</u>	The use of one or more physical techniques to explore earth properties and processes.
<u>Fault surface.</u>	The surface along which dislocation has taken place.	<u>Gouge material.</u>	Finely ground material occurring between the walls of a fault, the result of grinding movements.

<u>Graywacke.</u>	A hard, dark-colored, sandstone composed primarily of highly angular quartz and feldspar in a clay matrix. Usually contains significant quantities of rock fragments.	<u>Left-lateral fault movement.</u>	Generally horizontal movement in which the block across the fault from an observer has moved to the left.
<u>Ground cracking.</u>	Cracks usually occurring in stiff surface materials resulting from differential ground movement.	<u>Lenticular.</u>	Shaped approximately like a double convex lens. When a mass of rock thins out from the center to a thin edge all around, it is said to be lenticular in form.
<u>Ground failure.</u>	A situation in which the ground does not hold together such as in landsliding, mud flows, liquefaction and the like.	<u>Liquefaction.</u>	A process by which a water saturated sand lens loses coherence when shaken. Involved is the collapse of sand grains into intergranular voids which induces an increase in pore pressure and loss of strength. This loss of strength leads to a quicksand condition in which objects can either sink or float depending on their density.
<u>Ground lurching.</u>	Undulating waves in soft saturated ground that may or may not remain after the earthquake.	<u>Lithology.</u>	The description of rock composition and texture from observation of hand specimens or outcrops.
<u>Ground strength.</u>	The limiting stress that ground can withstand without failing by rupture or continuous flow.	<u>Mafic pyroclastic rocks.</u>	Pyroclastic rocks containing a high proportion of dark colored (mafic) rock and mineral constituents such as basalt.
<u>Ground response.</u>	The reaction of the ground to earthquake shaking.	<u>Magnitude.</u>	The rating of a given earthquake is defined as the logarithm of the maximum amplitude on a seismogram written by an instrument of specified standard type at a distance of 62 miles from the epicenter. It is a measure of the energy released in an earthquake. The zero of the scale is fixed arbitrarily to fit the smallest recorded earthquakes. The scale is open ended but the largest known earthquake magnitudes are near 8-3/4. Because the scale is logarithmic, every upward step of one magnitude unit means a 32 fold increase in energy release. Thus, a magnitude 7 earthquake releases 32 times as much energy as a magnitude 6 earthquake. Magnitude is <u>not</u> the same as intensity.
<u>Group.</u>	A local subdivision of a series of rocks, based on lithologic features. It usually contains two or more formations.	<u>Melange.</u>	A mixture or complex of rocks.
<u>Hayward fault.</u>	A large and active branch of the San Andreas Fault System. It has been the center of many earthquakes, including the 1868 earthquake which was one of the largest ever to hit Northern California.	<u>Micro-earthquake.</u>	A very small earthquake having a magnitude of 2 or less on the Richter scale.
<u>Hummocky.</u>	Lumpy land, or in small uneven knolls. This condition is a sign of previous extensive landsliding.	<u>Microseismic Event.</u>	An earthquake or man-induced vibrations observable only with instruments.
<u>Hypocenter</u>	That point within the earth which is the center of an earthquake and the origin of its elastic waves.	<u>Miocene.</u>	An epoch of the upper Tertiary period. It ranges from 12 million to 26 million years before the present.
<u>Inactive faults.</u>	Identifiable faults which do not meet any of the criteria listed under "active faults".	<u>Modified Mercalli.</u>	See "intensity".
<u>Incompetent beds.</u>	Opposite of competent beds.	<u>Monitoring fault movement.</u>	Use of survey methods over a period of time to measure displacement caused by creep over a period of time.
<u>Inelastic deformation.</u>	Permanent deformation of materials either by flow, creep, or rupture.	<u>Morphology, slope.</u>	See "slope morphology."
<u>Intensity.</u> (See Table 1)	A nonlinear measure of earthquake size at a particular place as determined by its effect on persons, structures, and earth materials. The principal scale used in the United States today is the Modified Mercalli, 1956 version. Intensity is a measure of effects as contrasted with magnitude which is a measure of energy. They are not the same.	<u>Mudflow or mudslide.</u>	A flowage of heterogeneous debris lubricated with a large amount of water.
<u>Interstitial water.</u>	Water contained within the minute pores or spaces between the small grains or other units of rock.	<u>Normal fault.</u>	Vertical movement along a sloping fault surface in which the block above the fault has moved downward relative to the block below.
<u>Intrusion.</u>	An igneous rock that has been injected into older rocks; it has cooled and solidified from a molten condition under the cover of the surrounding rock mass.	<u>Period, natural.</u>	See "natural period".
<u>Inundation.</u>	Flooding caused by water topping a dam or water released by dam, reservoir, levy or other break.	<u>Period, predominant.</u>	See "predominant period".
<u>Isoseismic line.</u>	An imaginary line connecting all points on the surface of the earth where an earthquake shock is of the same intensity.	<u>Physiography.</u>	A description of existing nature as displayed in the surface arrangement of the globe, its features, atmospheric and oceanic currents, climate, etc.
<u>Lacustrine.</u>	Formed in a lake.	<u>Plastic deformation.</u>	Under some conditions solids may bend instead of shearing or breaking as a result of seismic and geologic forces.
<u>Landsliding.</u>	The perceptible downward sliding or falling of a relatively dry mass of earth, rock, or mixture of the two. Often loosely used to also include sliding of wet earth masses such as mudslides and earthflows.	<u>Pliocene.</u>	The latest epoch in the Tertiary period. It ranges from 7 to 10 million to 2 to 3 million years before the present.

<u>Ponding.</u>	Accumulation of alluvial and colluvial deposits behind a fault-produced barrier.	<u>Slip, fault.</u>	See "fault slip".
<u>Precipitate.</u>	The material resulting from the process of separating mineral constituents from a solution by evaporation (salt, etc.) or from magma to form igneous rocks.	<u>Solid flow.</u>	Flow of a solid under long-time stress.
<u>Predominant period.</u>	A number representing the time between seismic wave peaks to which a building on the ground is most vulnerable. Usually measured in seconds.	<u>Strata.</u>	Layers of sedimentary rocks.
<u>Pumice.</u>	An excessively cellular, glassy lava of whitish or gray color. It is very light and will float on water.	<u>Strength, ground.</u>	See "ground strength".
<u>Pyroclastic.</u>	A general term for fragmental deposits of volcanic materials, including volcanic conglomerate, agglomerate, tuff and ash.	<u>Strike.</u>	See "attitude".
<u>Remote sensing.</u>	The acquisition of information or measurement of some property of an object by a recording device that is not in physical or intimate contact with the object under study. The technique employs such devices as the camera, lasers, infrared and ultraviolet detectors, microwave and radio frequency receivers, radar systems, etc.	<u>Strike-slip.</u>	Fault displacement parallel to the strike of the fault. See "attitude" and "slip".
<u>Residual soil.</u>	A soil deposit formed by the decay of rock in place.	<u>Strong motion.</u>	Ground motion produced by a "strong" earthquake or one capable of producing damage to structures. The magnitude of such an earthquake may vary considerably according to the character of the earthquake.
<u>Reverse or thrust fault.</u>	Vertical or nearly horizontal movement along a sloping fault surface in which the block above has moved upward or over the block below the fault.	<u>Structural feature.</u>	Features produced in the rock by movements after deposition, and commonly after consolidation, of the rock.
<u>Right-lateral fault movement.</u>	Generally horizontal movement in which the block across the fault from an observer has moved to the right.	<u>Subsidence.</u>	A shrinking of a large area of land, usually observed as a shrinkage.
<u>Sag ponds.</u>	Ponds occupying depressions along active faults. The depressions are due to uneven settling of the ground.	<u>Surface wash.</u>	A loose surface deposit of sand, gravel, boulders, etc.
<u>Sand boils.</u>	Turgid upward flow of water and some sand to the ground surface resulting from increased ground water pressures when saturated cohesionless materials are compacted by earthquake ground vibrations.	<u>Syncline.</u>	A trough-shaped fold in rocks in which the strata dip inward from both sides toward the axis. The opposite of anticline.
<u>Scarp.</u>	An escarpment, cliff, or steep slope of some extent along the margin of a plateau, terrace, bench, and at the top of a slide.	<u>Tectonic.</u>	Pertaining to or designating the rock structure and external forms resulting from the deformation of the earth's crust. Pressures causing such deformations often result in earthquakes.
<u>Sediment.</u>	Solid material settled from suspension in a liquid.	<u>Trace, fault.</u>	See "fault trace".
<u>Sedimentary rocks.</u>	Rocks, commonly stratified, formed by the accumulation of sedimentation in water or from air.	<u>Thrust fault.</u>	See "reverse fault".
<u>Seismograph.</u>	An instrument that writes a permanent continuous record of earth vibrations.	<u>Topography.</u>	The physical features of the land, especially its relief and contour.
<u>Seismic.</u>	Pertaining to an earthquake or earth vibration, including those that are artificially induced.	<u>Torsional forces.</u>	Forces which act to twist the object in question.
<u>Seismology.</u>	The science of earthquakes and related phenomena.	<u>Tsunami.</u>	A sea wave produced by large areal displacements of the ocean bottom, often the result of earthquakes or volcanic activity. Also known as seismic sea waves.
<u>Seismometer.</u>	A device which detects vibrations of the earth, and whose physical constants are known sufficiently for calibration to permit calculation of actual ground motion from the seismograph.	<u>Unconformity.</u>	In sedimentary rocks sometimes strata of intermediate age between younger and older rocks are absent. This is usually caused by total erosion of the middle-aged sediment before the younger sediment was deposited.
<u>Shear.</u>	A mode of failure whereby two adjacent parts of a solid, slide past one another parallel to the plane of contact. To subject a body to shear, similar to the displacement of the cards in a pack relative to one another.	<u>Unconsolidated material.</u>	Opposite of "consolidated material".
		<u>Undulating waves.</u>	Waves that rise and fall.
		<u>Water Table.</u>	The upper surface of a zone of water saturation within the ground.
		<u>Wash, surface.</u>	See "surface wash".
		<u>Wave height.</u>	The difference in elevation between adjoining wave crests and troughs.

APPENDIX II

OPTIONS MATRIX

A list of rather specific options were provided with each hazard discussed. These represent only a fraction of the possible responses to a hazardous situation. The Options Matrix is designed to expand upon the previous offerings by illustrating a methodology for evolving additional options.

Following an assessment of the hazard and determination that some action should be taken, the first step in using the matrix is to identify the resources affected by a hazard and select those which are to be addressed. The second step is to choose an appropriate response to the situation in question. The Matrix offers a range of resources and responses.

Before one can actually formulate an option or recommendation, one must also consider such things as: which hazard zone (high, moderate, low) should be addressed, the use of various qualifiers (all, most, some, etc.) and the time period for implementation. Some examples of recommendations in the form of policy statements derived from the Matrix follow:

All permanent structures for human habitation located in high hazard zone (within 25 feet of the fault trace of an active fault) shall be removed within ten (10) years.

All property owners within the high and moderate hazard zones shall be notified of the existence and potential extent of the ground shaking hazard within one year of the adoption of this policy.

RESPONSES

OPTIONS MATRIX

Remove	Prohibit	Limit	Discourage	Inspect for deficiencies	Up-grade to code	Warn of hazardous condition	Further study	Up-grade code	Review & practice warning plans	RESOURCES
										Structures
										Structures for human habitation
										Multiple dwelling units
										High temporary concentrations of people
										Public buildings and facilities
										Vital public services (police, fire, water, etc.)
										Sensitive facilities (hospitals, resthomes)
										High risk facilities (oil storage, chemical)

Other Considerations:

1. Qualifiers of Resources: all, some, most,
2. Time period of implementation: immediately, in 6 months,
3. Which hazard zone: high, medium and low.

HAZARDS PLATE I of the SEISMIC & SAFETY ELEMENTS RESOURCES PLAN & PROGRAM

Ventura County Planning Department
October 1974

VENTURA COUNTY
CALIFORNIA

GENERAL COUNTY MAP



FAULT PATTERNS

boundary
active or probable historic or moderate time
zone 5 with certain fault 5 which have been
geologically confirmed active faults
NOTE: Zone boundaries are approximately located

FAULT PATTERNS

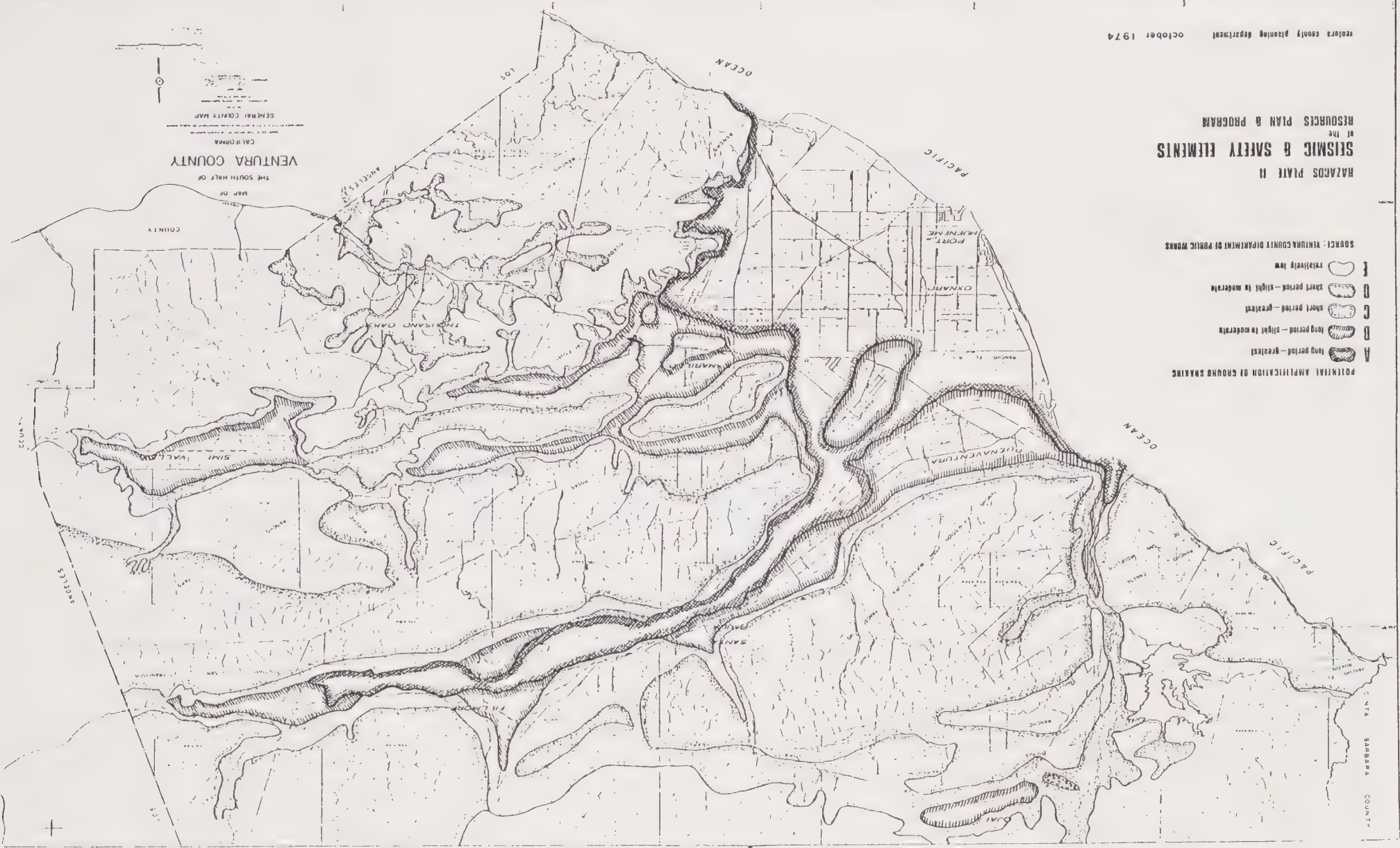
POSITIVELY IDENTIFIED
RELATIVELY WELL IDENTIFIED AND/OR RELATIVELY
CONCEALED
TYPICAL SYMBOLS DENOTES
DOWN-DIP SIDE OF FAULT
SOURCE: CALIF. DIV. OF MINES & GEOLOGY
VENTURA COUNTY DEPT. OF PUBLIC WORKS



HAZARDS PLATE II **SEISMIC & SAFETY ELEMENTS** **of the** **RESOURCES PLAN & PROGRAM**

ventura county planning department
 october 1974

- POTENTIAL AMPLIFICATION OF GROUND SHAKING
- A long period - greatest
 - B long period - slight to moderate
 - C short period - greatest
 - D short period - slight to moderate
 - E relatively low
- SOURCE: VENTURA COUNTY DEPARTMENT OF PUBLIC WORKS



VENTURA COUNTY

MAP OF THE SOUTH HALF OF

CALIFORNIA

GENERAL COUNTY MAP

SCALE

0 1 2 3 4 5 6 7 8 9 10

MILES

0 1 2 3 4 5 6 7 8 9 10

KILOMETERS

HAZAROUS PLATE II at the SEISMIC & SAFETY ELEMENTS RESOURCES PLAN & PROGRAM

ventura county planning department may, 1974
october 1974

MAP OF
THE NORTH HALF OF
VENTURA COUNTY
CALIFORNIA

GENERAL COUNTY MAP
SCALE 1:50,000



POTENTIAL APPLICATION OF GROUND SHAKING

- A LONG PERIOD - GREATEST
- B-C SHORT PERIOD - MODERATE
- D SHORT PERIOD - SLIGHT TO MODERATE
- E RELATIVELY LOW
- FOODCUT
- VENTURA COUNTY DEPARTMENT OF PUBLIC WORKS
- PRIVATE LANDS WITHIN NATIONAL FOREST



HAZARDS PLATE III SLUICING & SAFETY ELEMENTS

of the
resources plan & program

ventura county planning department
october, 1974

- selected channels
- designated flood plains
- standard project
- intermediate regional (100 year)
- area possibly subject to 50 year
- source u.s. army corps of engineers
- source ventura county flood control district
- source: u.s.d. soil conservation service

VENTURA COUNTY

GENERAL COUNTY MAP

CA. 1800 P.M.

MAP OF

COUNTY



HAZAROUS PLATE IV SEISMIC & SAFETY ELEMENTS of the RESOURCE PLAN & PROGRAM

- * Source Ventura County Dept. of Public Works
- * Source California Div. of Mines & Geology
- Airport Accident Hazard Zone
- active beach erosion
- little or no
- intermediate
- high
- hazardous / moderate hazard zones
- exist hazardous zones

ventura county planning department
october, 1974

VENTURA COUNTY

THE SOUTH HALF OF
CALIFORNIA

GENERAL COUNTY MAP

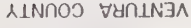


prepared by
ventura county planning department
october, 1974

„Ktoż przeżył (wzrusz)”

moderate - water table 15 to 40 from surface

High - water level 12:15 (4:15 PM) - 4010



MAP OF
THE SOUTH HALF OF

COUNTY

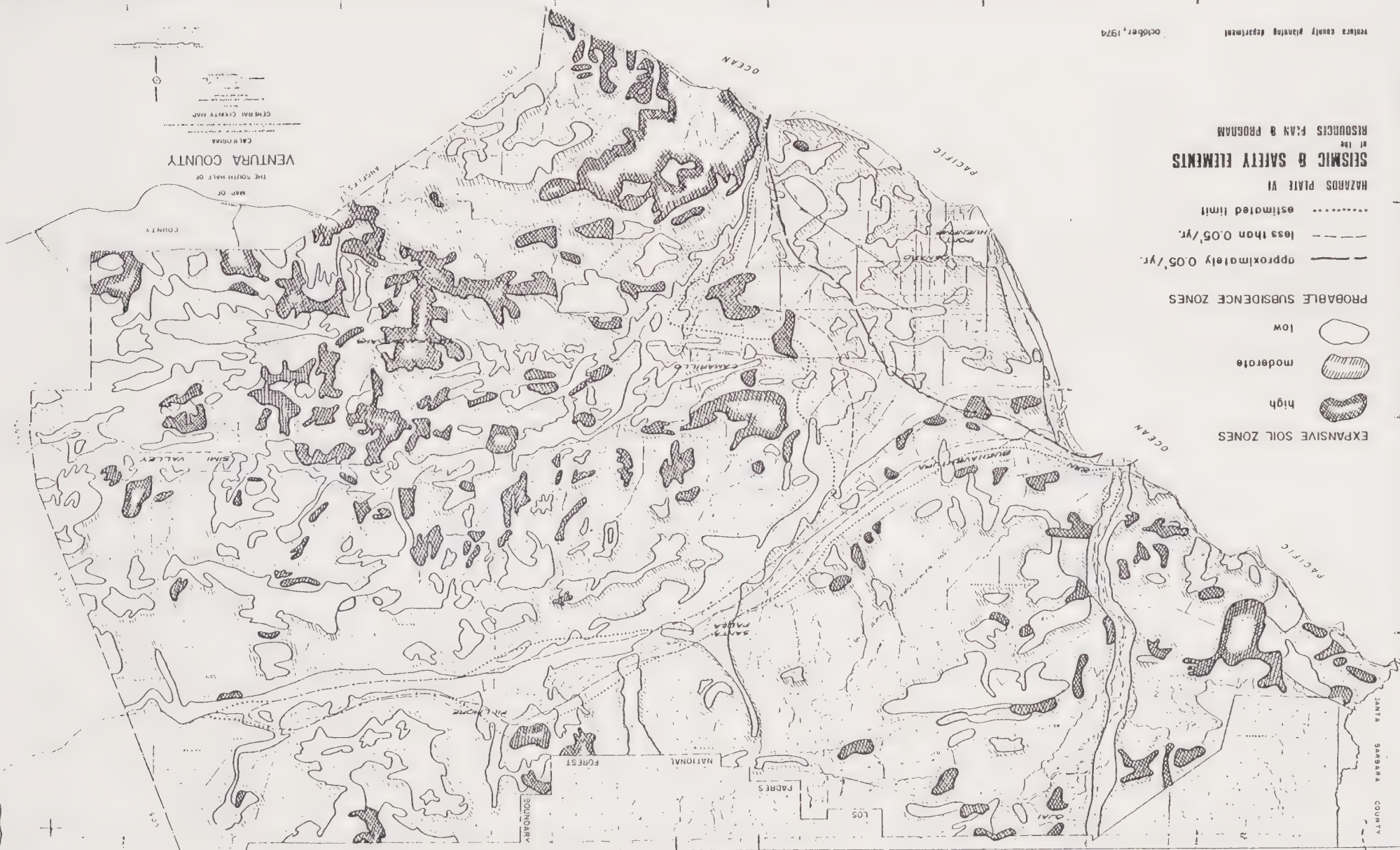
.....	estimated limit
— — — — —	less than 0.05%
—————	approximately

MOI

moderate

ყბიყ 

EXPANSIVE SOIL ZONES



VENTURA COUNTY

THE SOUTH HALF OF

10

APPENDIX

HAZARUS PLATE VIII SEISMIC & SAFETY ELEMENTS of the RESOURCES PLAN B PROGRAM

Prepared by

ventura county planning department

October 1974

SOURCE: U. S. GEOLOGICAL SURVEY &
CALIFORNIA DIV. OF FORESTRY

fire hazard
extreme
moderate
low



VENTURA COUNTY

CALIFORNIA

GENERAL COUNTY MAP

MAP OF

THE SOUTH HALL OF

COUNTY

COUNTY

SANTA BARBARA COUNTY

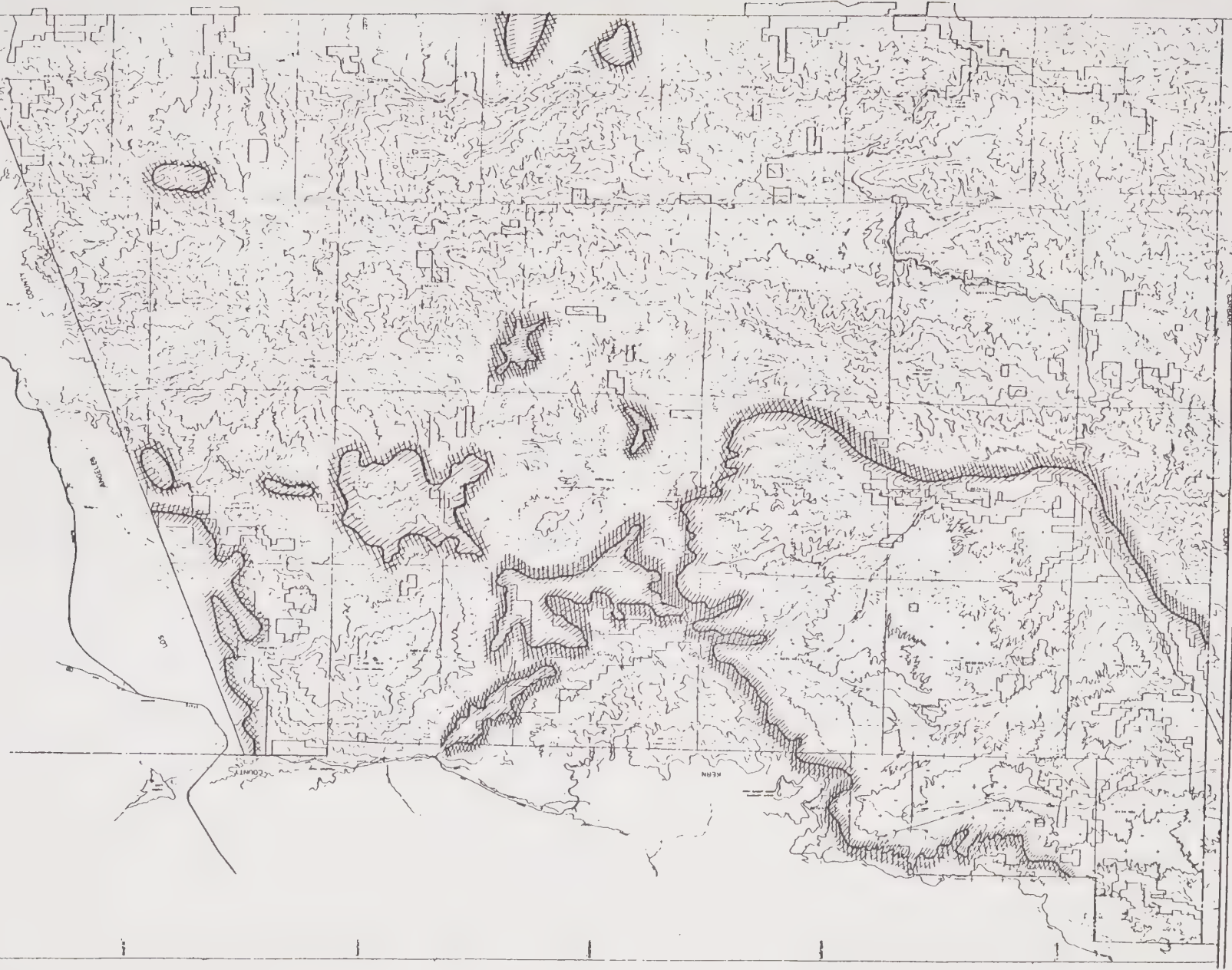
HAZARDOUS PLATE VIII
SEISMIC & SAFETY ELEMENTS
 of the
RESOURCES PLAN & PROGRAM

LOW HAZARD
MODERATE
EXTREME

SOURCE: VENTURA COUNTY PLANNING DEPARTMENT
 FROM AERIAL PHOTOGRAPHS

VENTURA COUNTY PLANNING DEPARTMENT OCT. 1979
 PRIVATE LANDS WITHIN NATIONAL FOREST

MAP OF
 THE NORTH HALF OF
 VENTURA COUNTY
 CALIFORNIA
 GENERAL COUNTY MAP



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